Datasheet ESCP-MIS1

MEMS Capacitive Pressure & Temperature Sensor for gases & liquids.

- State of the art performance due to MEMS capacitive technology
- Outstanding overpressure tolerance (up to 100x)
- Absolute operation
- Full scale pressure sensor options from 10 to 350 bar
- Temperature sensor: -40°C to +125°C
- Calibrated & temperature compensated output
- I²C, SPI or analog interface
- Excellent accuracy, resolution, long term stability
- Low power consumption
- No external components required

Product Summary

ES Systems has developed a series of medium isolated pressure sensors suitable for applications with harsh environmental conditions where resistance to corrosive fluids or gases is required. Each sensor integrates a MEMS capacitive pressure sensor die, and a CMOS ASIC for the signal conditioning. The MEMS pressure sensor dies are underpinned by ES Systems' innovative microfabrication process for silicon capacitive sensors.

The capacitive pressure sensor dies integrated into the medium isolated pressure systems provide state-of-the-art accuracy and resolution, excellent long-term stability combined with very good repeatability and hysteresis. The total overall error including thermal offsets is lower than ±0.25% FS.

The ESCP-MIS1 is a family of pressure sensors in the standard Ø19 stainless steel 316L capsule. In this type of sensors, the pressure is transferred hydraulically to the hermetically sealed sensing element through the oil used to fill the cavity between the sensing element and the stainless steel diaphragm. The pressure capsule interface is either I²C, SPI or analog. The sensors are provided calibrated and compensated at various temperature and pressure ranges from 10 bara to 350 bara. Custom materials like Hastelloy or Titanium are available upon request.

Typical Applications

- Gas, Liquid Pressure Measurement
- Corrosive Fluids and Gas Measurement Systems
- Sealed Systems
- Manifold Pressure Measurement
- Submersible Depth Monitoring
- Medical Instruments
- Industrial Process Control
- Pressure Calibrator
- Pressure Transmitter Integration
- Refrigeration Equipment & Air Conditioner
- OEM equipment

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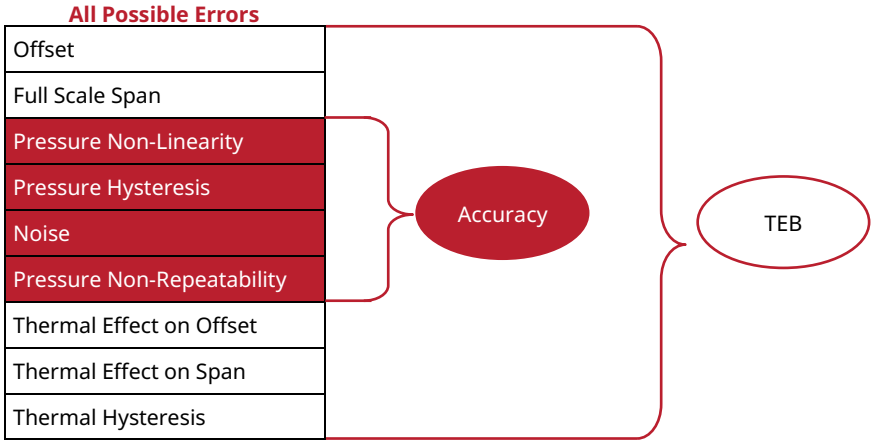
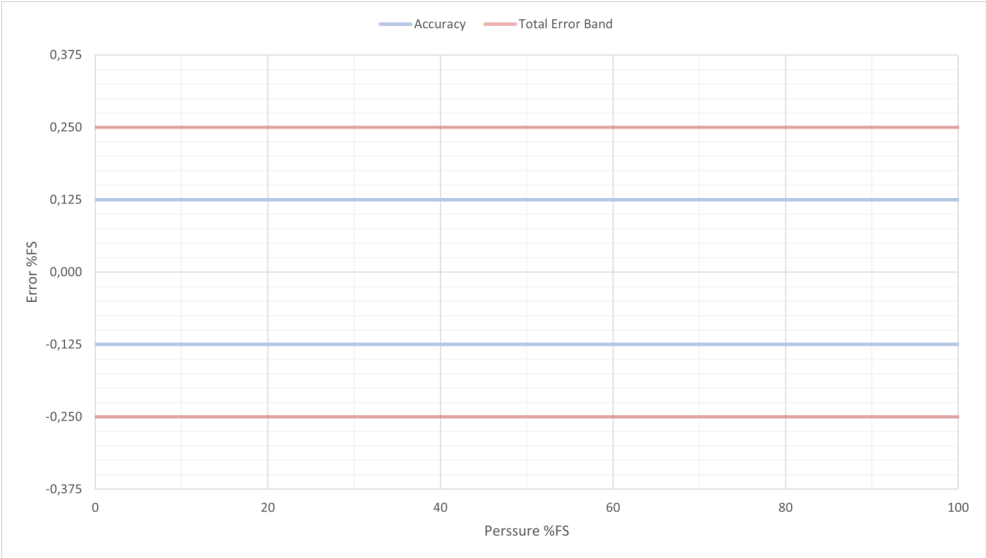
1. Total Error Band

Total Error Band (TEB) is a single specification that includes all possible sources of error in a pressure measurement. TEB should not be confused with accuracy, which is actually a component of TEB. TEB is the worst error that the sensor could experience. The TEB specification on a datasheet may be confusing. ES Systems uses the TEB specification in its datasheet because it is the most comprehensive measurement of a sensor's true accuracy. ES Systems also provides the accuracy specification in order to provide a common comparison with competitors' literature that does not use the TEB specification.



The figure below, illustrates the accuracy as well as the total error of the pressure measurement of ESCP-MIS1 sensors.



Accuracy Performance

Range: 10, 12, 13, 14, 18, 20, 28, 30, 35, 70, 100, 200, 350 bar

0% FS to 100%FS = ±0.125%FS

Total Error Band Performance

Range: 10, 12, 13, 14, 18, 20, 28, 30, 35, 70, 100,

0% FS to 100%FS = ±0.25%FS

Range: 200, 350 bar

0% FS to 100%FS = ±0.5%FS

2. Absolute Maximum Ratings[1]

Characteristic	Min.	Max.	Unit
Supply voltage (V_{supply})	3.1	5.5	Vdc
Voltage on any pin	-0.3	5.5	V
Current on any pin	-	2	mA
Burst pressure	-	1000	bara
Storage temperature	-40[-40]	+125[+257]	°C[°F]
Maximum pressure applied	-	1000	bara

[1] Absolute maximum ratings are the extreme limits the device will withstand without damage. The electrical and performance characteristics are not guaranteed as the maximum limits are approached, nor will the device necessarily operate as specified at absolute maximum ratings. Prolonged operation at absolute maximum ratings will degrade the device performance

CAUTION
IMPROPER HANDLE
Do not touch the sensing membrane.
Failure to comply with the instructions may result in product damage.

CAUTION
PRODUCT DAMAGE
Do not disassemble these products.
Failure to comply with the instructions may result in product damage.

3. Operating Specifications

Characteristic	Min.	Typ.	Max.	Unit
Supply voltage (V_{supply})[1]	3.1	3.3	5.5	V
Supply current	-	-	2.3	mA
Output	Calibrated Pressure & Temperature			-
Output Interface	I²C, SPI, Analog (0.5 to 2.5V)			-
Digital bus frequency	-	-	100	kHz
SPI t_{setup}	100	150	1000	usec
I²C/SPI voltage Level Low High	 - 80	 - -	 20 -	 %V_{supply}
Pull up on SDA / SCL	4.7	-	-	kOhm
Analog Output Resistance	10k	-	-	Ohm
Start-up time[2]	-	30	-	msec
Operating temp. range	-40[-40]	-	+125[+257]	°C[°F]
Relative humidity (non-condensing)	-	-	100	% RH
Material	Stainless Steal, Titanium, Hastelloy			-
Filling Oil	Silicon, Food, Fluorinated			
Sealing type	O-ring (FKM, EPDM, NBR, VMQ, HNBR), weld			-
Media Compatibility	Gases, liquids			-

[1]The sensor is not reverse polarity protected. Incorrect application of supply voltage or ground to the wrong pin may cause electrical failure.
[2]After 95% of V_{supply} reached.

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4. Pressure Sensor Specifications

Characteristic	Absolute			Unit
	Min.	Typ.	Max.	
Pressure Type	absolute			-
Pressure Range	Up to 350			bara
Full scale ranges	10, 12, 13, 14, 18, 20, 28, 30, 35, 70, 100, 200, 350			bara
Compensated temp range[1] Option 01 Option 02 Option 03	 0[32] -20[-4] -40[-40]	 - - -	 +60[+140] +85[+185] +125[+257]	°C[°F]
Effective Resolution Response Time (10Hz) Response Time (1kHz)	 - -	 12 10	 - -	bits
Total error band[2] < 100 bar 0 to +60 °C -20 to +85 °C -40 to +125 °C Total error band > 100 bar 0 to +60 °C -20 to +85 °C -40 to +125 °C	 - - - - - -	 ±0.25 ±0.25 ±0.25 ±0.5 ±0.5 ±0.5	 - - - - - -	%FS[3]
Accuracy[4]	-	±0.125	-	%FS
Long term stability[5]	-	-	±0.25	%FSS[6]

[1] The temperature range over which the sensor will produce an output proportional to pressure within the specified performance limits. Note that for valid datasheet values, ambient and medium temperatures must be the same

[2] The maximum deviation from ideal transfer function over the entire compensated temperature and pressure range. Includes all errors due to offset, full scale span, accuracy, thermal effect on offset, thermal effect on span and thermal hysteresis

[3] % of the full scale

[4] The maximum deviation in output from a Best Fit Straight Line (BFSL) fitted to the output measured over the pressure range at 21°C [69.8°F]. Includes all errors due to pressure non-linearity, pressure hysteresis, non-repeatability and noise

[5] Accelerated Life Test Profile: 100hours at 90°C

[6] Full Scale Span (FSS): The algebraic difference between the output signal measured at the maximum (P_{max}) and the minimum (P_{min}) limits of the pressure range

5. Temperature Sensor Operating Specifications

Characteristic	Min.	Typ.	Max.	Unit
Full Scale range	-40[-40]	-	+125[+257]	°C[°F]
Accuracy	-	0.5	-	°C
Resolution	14	-	-	bits
Output Rate	-	250	-	msec

6. Pressure Range Specifications

Pressure Range	Pressure Range		Unit	Proof Pressure[1]	Burst Pressure[2]
	P_{min}	P_{max}		Port	Port
Absolute					
010BA	0.25	10	bar	1000	1000
012BA	0.25	12	bar	1000	1000
013BA	0.25	13	bar	1000	1000
014BA	0.25	14	bar	1000	1000
018BA	0.5	18	bar	1000	1000
020BA	0.5	20	bar	1000	1000
028BA	0.5	28	bar	1000	1000
030BA	0.5	30	bar	1000	1000
035BA	0.5	35	bar	1000	1000
070BA	0.5	70	bar	1000	1000
100BA	1	100	bar	1000	1000
200BA	1	200	bar	1000	1000
350BA	1	350	bar	1000	1000

[1] Overpressure: The maximum pressure which may safely be applied to the product for it to remain in specification once pressure is returned to the operating pressure range. Exposure to higher pressures may cause permanent damage to the product. Unless otherwise specified this applies to all available pressure ports at any temperature with the operating temperature range

[2] Burst pressure: The maximum pressure that may be applied to the specified port (P1 or P2) of the product without causing escape of pressure media. Product should not be expected to function after exposure to any pressure beyond the burst pressure

7. Wetted Matterials[1]

Component	Pressure Port Dry Gas or Liquid Media
Material	Stainless Steel 316L[2]
O-ring	FKM[3]
Weight	17g

[1] Contact ESS Customer Service for detailed material information

[2] Titanium, Hastelloy are also available

[3] EPDM, NBR, VMQ, HNBR are also available

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8. Data & Register Description

The ESCP-MIS1 sensors provide measurement and status data. The measurement data are **Pressure** and **Temperature**. The data are stored in specific data registers as described below. The readout is performed by using multibyte read transactions. Both I^2C and SPI communication share the same structure. First byte is the register address which defines the appropriate register to be written/read and then follows the payload in either direction. The difference between the two serial interfaces is that in I^2C version the user need to address ESCP-MIS1 device and confirm each byte reception/transmit by receiving an ack after each transaction.

Result Registers [0x0X]

After every conversion is completed, based on the programed rate and data output, ECSP-MIS1 sensor updates the corresponding data registers values. Data are in IEEE-754 floating point format (32bit) and are returned in MSB first sequence.

ADDRESS	REGISTER NAME	TYPE	DEFAULT VALUE (Hex)	MNEMONIC
0x01	Calibrated Pressure Byte 1	R	Variable	CAL_PRESS_DATA[31:24]
	Calibrated Pressure Byte 2	R	Variable	CAL_PRESS_DATA[23:16]
	Calibrated Pressure Byte 3	R	Variable	CAL_PRESS_DATA[15:8]
	Calibrated Pressure Byte 4	R	Variable	CAL_PRESS_DATA[7:0]

Address 0x01 holds the pressure result in bars. The lowest and highest value depends on the pressure range of the sensor and cannot exceed the maximum range. Over and under pressure conditions are indicated in status register (see the corresponding register 0x13).

An example of a pressure measurement is:

Calibrated Pressure Byte 1 = 0x40

Calibrated Pressure Byte 2 = 0xAB

Calibrated Pressure Byte 3 = 0x85

Calibrated Pressure Byte 4 = 0x1E

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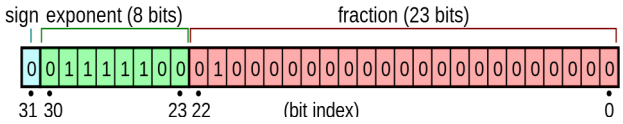
The result is represented in the IEEE 754 format and any device that has a IEEE 754 compatible arithmetic unit does not need to convert it.

IEEE 754 float format conversion:

IEEE 754 format consists of 3 parts: the sign bit (bit 32), exponent part (bits 30:23), mantissa or fractional part (bits 22:0) as shown in the example above:



The sign bit (s) represents the sign of the number and it is positive (+) for 0 and negative (-) for 1. For the absolute value of the number we need to calculate the mantissa and the exponent part. The 8 bits of the exponent part are translated as an unsigned integer ranging from 0 to 255 with offset 127. For the mantissa part we need to calculate the above sum:

$$m = \sum_{n=0}^{22} bit_n \times 2^{-n}$$

After calculating the above the final result is given by the equation:

$$P = (-1)^{sign} \times 2^{e-127} \times m$$

In the example for 0x40AB851E (b0100 0000 1010 1011 1000 0101 0001 1110) we get:

Sign = 0,

Exponent = 129,

Mantissa = 1.33999991417

Finally pressure measured is P = + 1.33999991417 X 2 $^{130\text{-}127}$ = 5.36 bar

Embedded software conversion:

In practice, the user should just cast the received bytes from registers 0x0X to a float variable with IEEE 754 format and the calculations will be done automatically by the compiler.

ADDRESS	REGISTER NAME	TYPE	DEFAULT VALUE (Hex)	MNEMONIC
0x02	Calibrated Temperature Byte 1	R	Variable	CAL_TEMP_DATA[31:24]
	Calibrated Temperature Byte 2	R	Variable	CAL_TEMP_DATA[23:16]
	Calibrated Temperature Byte 3	R	Variable	CAL_TEMP_DATA[15:8]
	Calibrated Temperature Byte 4	R	Variable	CAL_TEMP_DATA[7:0]

Address 0x02 holds the temperature result in degrees Celsius . The conversion from IEEE 754 format is the same as for register 0x01.

ADDRESS	REGISTER NAME	TYPE	DEFAULT VALUE (Hex)	MNEMONIC
0x00	Calibrated Pressure Byte 1	R	Variable	CAL_PRESS_DATA[31:24]
	Calibrated Pressure Byte 2	R	Variable	CAL_PRESS_DATA[23:16]
	Calibrated Pressure Byte 3	R	Variable	CAL_PRESS_DATA[15:8]
	Calibrated Pressure Byte 4	R	Variable	CAL_PRESS_DATA[7:0]
	Calibrated Temperature Byte 1	R	Variable	CAL_TEMP_DATA[31:24]
	Calibrated Temperature Byte 2	R	Variable	CAL_TEMP_DATA[23:16]
	Calibrated Temperature Byte 3	R	Variable	CAL_TEMP_DATA[15:8]
	Calibrated Temperature Byte 4	R	Variable	CAL_TEMP_DATA[7:0]

Address 0x00 returns all available results sequentially. Reading register 0x00 equals reading sequentially the results at registers 0x01, 0x02 without having to start a new transaction. It is especially convenient when the user wants to read calibrated pressure and temperature on one I^2C transaction.

Info and Status registers [0x1X]

The 0x1X registers set provides info for the specific device, firmware version and working status. Also provides the user the means to perform a software reset of the device.

ADDRESS	REGISTER NAME	TYPE	DEFAULT VALUE (Hex)	MNEMONIC
0x10	Software reset	-	No payload	-

Addressing register 0x10 results in a software reset of the ESCP-MIS1 device right after the reception of the register address. This will reset the settings that the user programed during the last operation cycle and will return the device on its default state.

ADDRESS	REGISTER NAME	TYPE	DEFAULT VALUE (Hex)	MNEMONIC
0x11	Product Family Code Byte 1	R	Fixed ID	PFC[7:0]
	Product Family Code Byte 2	R	Fixed ID	PFC[15:8]
	Product code Byte 1	R	Fixed ID	PC[7:0]
	Product code Byte 2	R	Fixed ID	PC[15:8]
	Lot number	R	Fixed ID	LOT_NUMBER [7:0]
	Serial number 1	R	Fixed ID	SERIAL_NUMBER[7:0]
	Serial number 2	R	Fixed ID	SERIAL_NUMBER[15:8]

Register 0x11 contains a unique, to every ESCP-MIS1 pressure sensor, serial number that consists of 4 parts: [Product Family Code]-[Product Code] [Lot number]-[Serial Number]. For example the serial number 0x8803530104001C translates to: 904-339 04-0028

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ADDRESS	REGISTER NAME	TYPE	DEFAULT VALUE (Hex)	MNEMONIC
0x12	Fw version Major	R	Fixed version	MAJOR_VER[7:0]
	Fw version Minor	R	Fixed version	MINOR_VER[7:0]
	Fw version sub-Minor	R	Fixed version	SUB_MINOR_VER[7:0]

Register 0x12 contains the firmware version of the ESCP-MIS1 capsule. First Byte is the major version number, second number is the minor firmware version and the last Byte represents the sub minor firmware version.

ADDRESS	REGISTER NAME	TYPE	DEFAULT VALUE (Hex)	MNEMONIC
0x13	Status Register	R	Variable	RUNNING_BIT[7:7]
				RESERVED[6:2]
				OVER_PRESSURE[1:1]
				UNDER_PRESSURE[0:0]

Register 0x13 returns the ESCP-MIS1 status vector.

RUNNING_BIT : when the device ha started conversions the bit is 1. If the conversions are not started or the user has stopped the conversions then the bit is 0

RESERVED: internal functionality should return 0

OVER_PRESSURE: when the pressure sensor is exposed in pressure over the rated pressure range the bit is set to 1 and the result is clipped.

UNDER_PRESSURE: when the pressure sensor is exposed in pressure under the rated pressure range the bit is set to 1 and the result is clipped.

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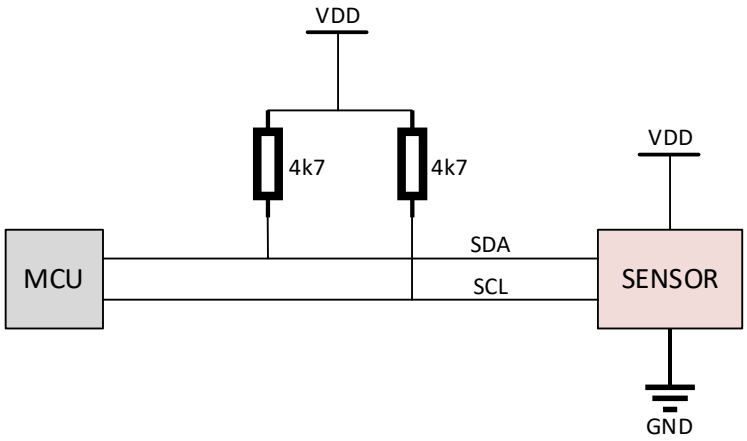
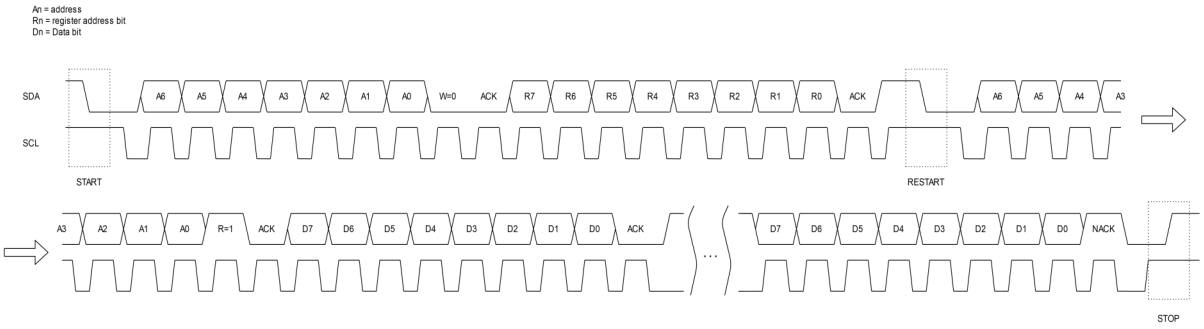
9. I²C Interface



At power on reset, the sensor needs 30ms to initialize. After that time the device is ready to communicate as an I2C slave device with 7-bit address **0x28.**

If the master device transmits the selected sensor 7-bit address (**0x50**) with R/W bit **set**, and the appropriate register address, the sensor returns the result specified in the previous section after acknowledging (ACK) by holding the SDA line low. In order for the master to receive the data requested, should send 8 clock pulses for each data byte and provide an acknowledge bit at the 9th clock cycle by holding the SDA line low. When the last byte is received a stop condition is issued from the master indicating the termination of the transaction.

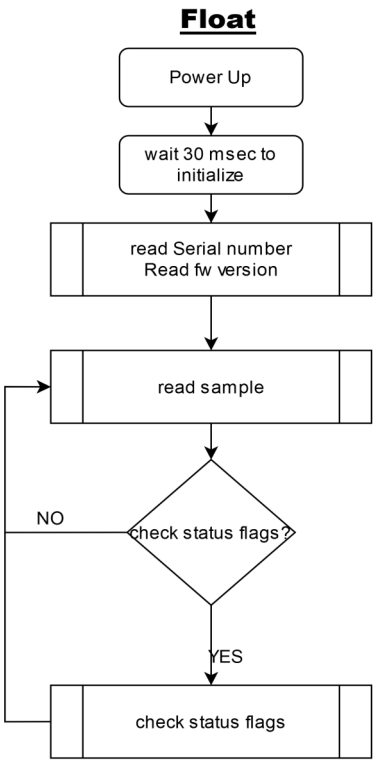
An example of such a transaction is shown below.



I²C Read

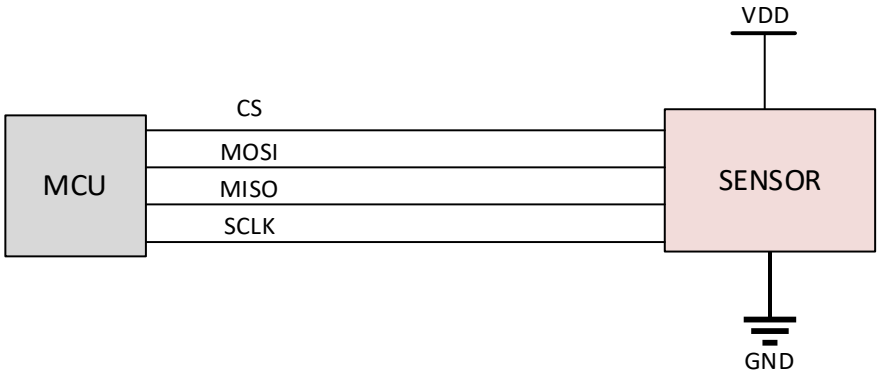
I2C communication example

A typical use case is presented bellow. The user powers up the ESCP-MIS1 either by applying power to the system or by sending a reset command to the device. After initializing, the user reads the device's serial number and firmware version and reads the pressure and temperature values periodically. At any time the user can read the status register to check that the sensor is converting and the maximum or minimum pressure limit is not exceeded



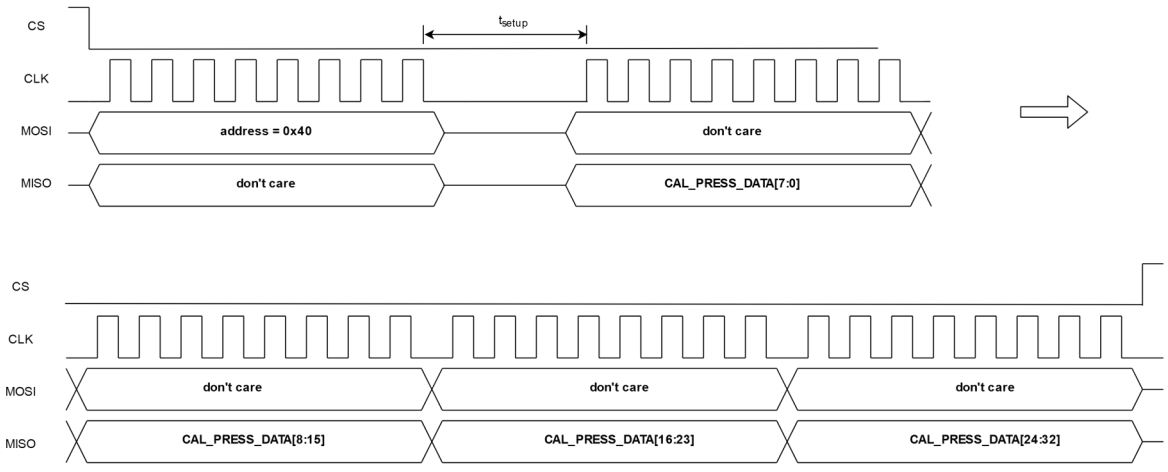
Function	I2C Transaction example
Wait for the sensor to initialize	
Read serial number and fw version	**(I2C):[S] 0x50 0x11 [S] 0x51 0x88 0x03 0x53 0x01 0x04 0x00 0x1C [P]** serial = 904-339 04-0028 **(I2C):[S] 0x50 0x12 0x01 0x01 0x00 [P]** fw version = 1.1.0
Read Pressure and temperature Sample	**(I2C):[S] 0x50 0x01 [S] 0x51 0x40 0xAB 0x85 0x1E [P]** pressure = 5.36 bar **(I2C):[S] 0x50 0x02 [S] 0x51 0x4A 0xCA 0x66 0x66 [P]** temperature = 25.2999992371
Read status register	**(I2C):[S] 0x50 0x13 [S] 0x51 0x01[P]** Running bit flag = 1 Over pressure flag = 0 Under pressure flag = 0

10. SPI Interface



SPI serial peripheral interface follows the same register mapping as described in section 8. The sensor uses mode 0 SPI with CPOL = 0 and CPHA = 0.

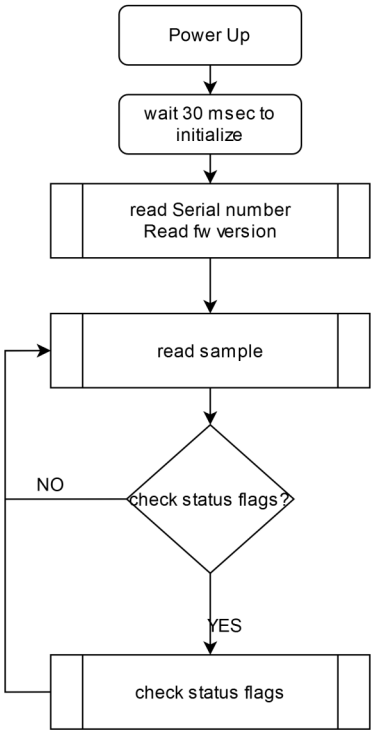
The SPI communication requires to send, via the MOSI signal, the address to read and then the following clock pulses will produce the required result on the MISO line. After the address setting the slave requires a t_{setup} time before issuing the data clock pulses in order to fetch the data to output buffer. The CS line should be driven low and kept low during the transaction. The following example describe the SPI transactions for reading the pressure output of the



SPI Read

SPI communication example

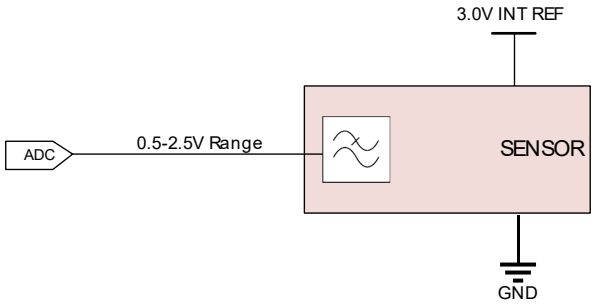
A typical use case is presented bellow. The user powers up the ESCP-MIS1 either by applying power to the system or by sending a reset command to the device. After initializing, the user reads the device's serial number and firmware version and reads the pressure and temperature values periodically. At any time the user can read the status register to check that the sensor is converting and the maximum or minimum pressure limit is not exceeded.



Float	Function	SPI Transaction example
Power Up		
wait 30 msec to initialize	Wait for the sensor to initialize	
read Serial number Read fw version	Read serial number and fw version	**(SPI-mosi): 0x11 0xXX 0xXX 0xXX 0xXX 0xXX 0xXX 0xXX** **(SPI-miso): 0xXX 0x88 0x03 0x53 0x01 0x04 0x00 0x1C** serial = 904-339 04-0028 **(SPI-mosi): 0x12 0xXX 0xXX 0xXX** **(SPI-miso): 0xXX 0x01 0x01 0x00** fw version = 1.1.0
read sample	Read Pressure and temperature Sample	**(SPI-mosi): 0x01 0xXX 0xXX 0xXX 0xXX** **(SPI-miso): 0xXX 0x40 0xAB 0x85 0x1E** pressure = 5.36 bar **(SPI-mosi): 0x02 0xXX 0xXX 0xXX 0xXX** **(SPI-miso): 0xXX 0x4A 0xCA 0x66 0x66** temperature = 25.2999992371
check status flags ?		
check status flags	Read status register	**(SPI-mosi): 0x13 0xXX** **(SPI-miso): 0xXX 0x01** Running bit flag = 1 Over pressure flag = 0 Under pressure flag = 0

0xXX = don't care

11. Analog Interface

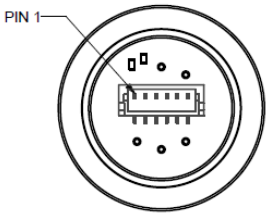


The analog output of the sensor is updated at the default digital rate of 10Hz. The calibrated output is in the range of 0.5 - 2.5 VDC . The output resistance of the sensor is 10kOhms. The user must ensure that the input of the ADC is at high enough impedance to allow elimination of potential voltage division errors.

12. Pinouts[2]

Output	PIN1	PIN2	PIN3	PIN4	PIN5	PIN6
I²C	NC[1]	SDA	SCL	NC	VDD	GND
SPI	CS	MOSI	SCLK	MISO	VDD	GND
Analog	NC	NC	NC	AOUT	VDD	GND

[1] Do not Connect
[2] Electrical Connection: BM06B-SRSS-TB(LF)(SN)



13. Environmental Specifications

Characteristic	Parameter
Vibration	20g for 5 to 2000 Hz
Shock	175g for 11ms and 100g for 1ms
ESD	ESD IEC6100-4-2 air discharge up to 8 kV, or direct contact discharge up to 4 kV
EMC/EMI	level 3 from 80 MHz to 1000 MHz per IEC61000-4-3, 1m shielded cable with 3cm exposed leads at connector.
Shelf Life	20 years
Life[1]	1 million pressure cycles minimum

[1] Life may vary depending on specific application in which the sensor is used

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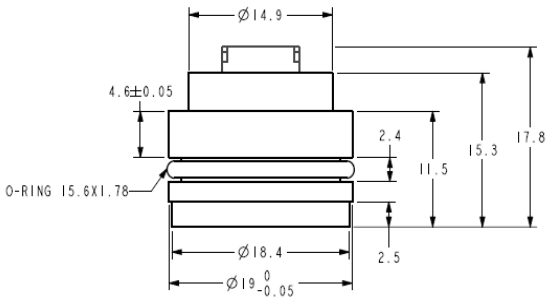
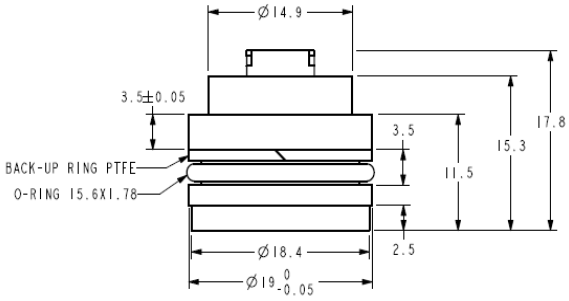
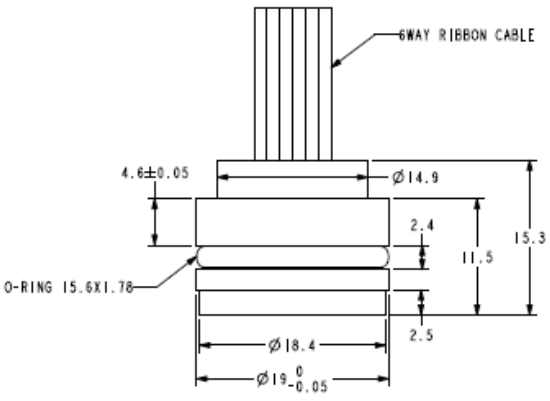
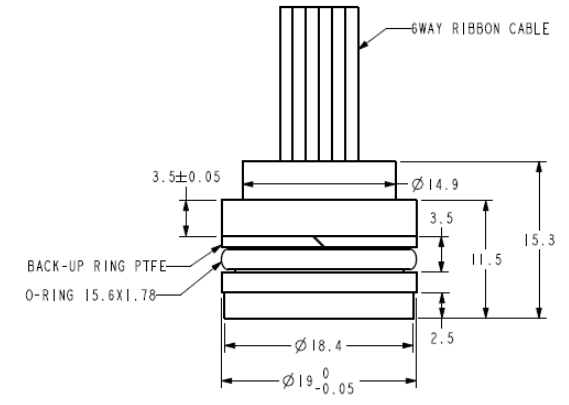
14. Mechanical Drawings (mm)

The drawings below show the standard mechanical dimensions of the ESCP-MIS1 sensor

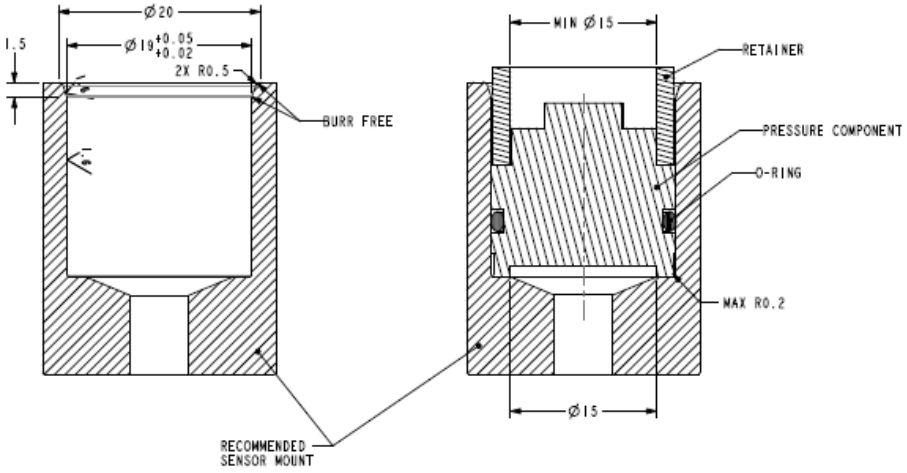
FS range ≤ 35 bar	FS range > 35 bar
	

The drawings below show the mechanical dimensions of the –40C to +125C option of the ESCP-MIS1 sensor

FS range ≤ 35 bar	FS range > 35 bar
	

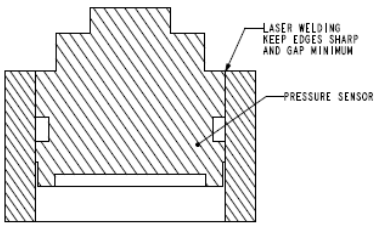
15. Instructions of Mounting

O-ring option



Recommended installation for pressure sensor with FKM O-ring for temperature range –20°C to +125°C. Working temperature range should be taken into account when designing the installation cavity. During installation, O-ring should be lubricated with suitable grease (In O_2 applications do no not use any grease).

Weld option



Recommended installation for pressure sensor with laser welding

16. Instructions of Operation

The ESCP-MIS1 sensor features digital temperature compensation. The temperature is measured on the MEMS element by an on-chip temperature sensor. This data is fed to a compensation circuit that is also integrated on the microprocessor. Thus, no external temperature compensation is necessary.

Sensor Handling

The ESCP-MIS1 sensor is designed to be robust and shock resistant. Nevertheless, the accuracy of the high-precision ESCP-MIS1 can be degraded by rough handling. ES Systems does not guarantee proper operation in case of improper handling.

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17. Ordering Information

ESCP-MIS1-N-NNNNN-NN-NN-NN-NN-NN-N-N

Pressure Type

1	Absolute

Pressure Range

Absolute	Full Scale
010BA	10 bar
012BA	12 bar
013BA	13 bar
014BA	14 bar
018BA	18 bar
020BA	20 bar
028BA	28 bar
030BA	30 bar
035BA	35 bar
070BA	70 bar
100BA	100 bar
200BA	200 bar
350BA	350 bar

Temperature Sensor

Y	Yes
N	No

Pressure Response Time

1	10Hz
2	1kHz

Output Type

01	I2C (address 0x28)	05	SPI
02	I2C (address 0x29)	06	Analog
03	I2C (address 0x2A)		
04	I2C (address 0x2B)		

Compensated Temperature

01	0°C to 60°C
02	-20°C to 85°C
03	-40°C to 125°C

Sealing Type

01	O-ring FKM
02	O-ring EPDM
03	O-ring NBR
04	O-ring VMQ
05	O-ring HNBR
06	Laser Weld

Filling Oil

01	Silicon
02	Food
03	Fluorinated

Material

01	SS316L
02	Hastelloy
03	Titanium

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Important Notes

PERSONAL INJURY

DO NOT USE these products as safety or emergency stop devices, or in any other application where failure of the product could result in personal injury.

Failure to comply with these instructions could result in death or serious injury.

WARRANTY

ES Systems warrants this Product to be free of defects in materials and workmanship for a period of one (1) year from the date of purchase.

Upon examination by ES Systems, if the unit is found to be defective it will be repaired or replaced at no charge. ES Systems' WARRANTY does not apply to defects resulting from any action of the purchaser, including but not limited to mishandling, improper interfacing, operation outside of design limits, improper repair, or unauthorized modification. This WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion; or current, heat, moisture or vibration;
improper specification; misapplication; misuse or other operating conditions outside of ES Systems' control. Components which wear are not warranted.

ES Systems neither assumes responsibility for any omissions or errors nor assumes liability for any damages that result from the use of its Product in accordance with information provided by ES Systems, either verbal or written. ES Systems warrants only that the parts manufactured by it will be as specified and free of defects.

ES SYSTEMS MAKES NO OTHER WARRANTIES OR REPRESENTATIONS OF ANY KIND WHATSOEVER, EXPRESSED OR IMPLIED, EXCEPT THAT OF TITLE, AND ALL IMPLIED WARRANTIES INCLUDING ANY WARRANTY OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE HEREBY DISCLAIMED.

No representative of ES Systems is authorized to extend this Warranty or to change it in any manner whatsoever.

No warranty applies to any party other than the original Customer. The remedies of the Customer set forth herein are exclusive and the total liability of ES Systems with respect to this order, whether based on contract, warranty, negligence, indemnification, strict liability or otherwise, shall not exceed the purchase price of the component upon which liability is based.

In no event shall ES Systems be liable for consequential, incidental or special damages.

Specifications may change without notice. The information supplied is believed to be accurate and reliable as of this issue; however, ES Systems assumes no responsibility for its use.

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