Honeywell

THE POWER OF **CONNECTED**

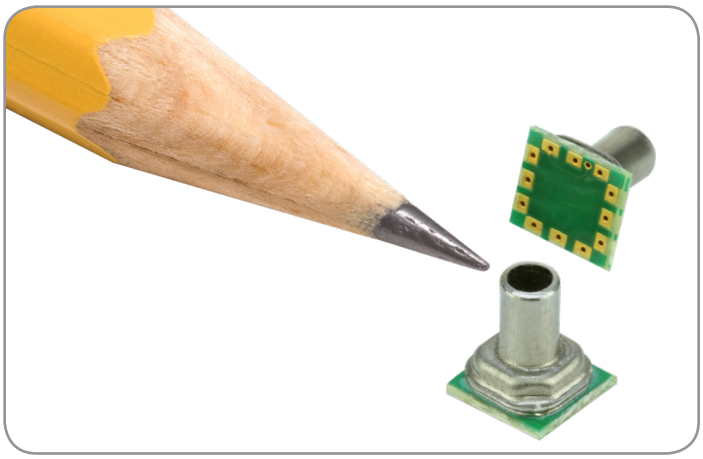
MicroPressure Board Mount Pressure Sensors

MPR Series—Compact, High Accuracy, Compensated/Amplified

32332628

Issue D

Datasheet



DESCRIPTION

The MPR Series is a very small piezoresistive silicon pressure sensor offering a digital output for reading pressure over the specified full scale pressure span and temperature range. It is calibrated and compensated over a specific temperature range for sensor offset, sensitivity, temperature effects, and non-linearity using an on-board Application Specific Integrated Circuit (ASIC). This product is designed to meet the requirements of higher volume medical (consumer and non-consumer) devices, commercial appliance, and industrial/HVAC applications.

VALUE TO CUSTOMERS

- Very small form factor: Enables portability by addressing weight, size, and space restrictions; occupies less area on the PCB.
- Wide pressure ranges simplify use.
- Enhances performance: Output accelerates performance through reduced conversion requirements and direct interface to microprocessors.
- Value solution: Cost-effective, higher volume solution with configurable options.
- Meets IPC/JEDEC J-STD-020D.1 Moisture Sensitivity Level 1 requirements: Allows avoidance of thermal and mechanical damage during solder reflow attachment and/or repair that lesser rated sensors may incur; allows unlimited floor life when stored as specified (simplifying storage and reducing scrap); eliminates lengthy bakes prior to reflow, and allows for lean manufacturing due to stability and usability shortly after reflow.
- Low power/energy efficient: Reduces system power requirements and enables extended battery life.

FEATURES

- 5 mm x 5 mm [0.20 in x 0.20 in] package footprint
- Calibrated and compensated
- 60 mbar to 2.5 bar | 6 kPa to 250 kPa | 1 psi to 30 psi
- 24-bit digital I^2C or SPI-compatible output
- IoT (Internet of Things) ready interface
- Low power consumption (<10 mW typ.), energy efficient
- Stainless steel pressure port
- Compatible with a variety of liquid media
- Absolute and gage pressure types
- Total Error Band after customer auto-zero: As low as ±1.5 %FSS
- Compensated temperature range: 0°C to 50°C [32°F to 122°F]
- REACH and RoHS compliant
- Meets IPC/JEDEC J-STD-020D.1 Moisture Sensitivity Level 1
- Select sensors available on breakout board for easy evaluation and testing

DIFFERENTIATION

- Application-specific design addresses various application needs and challenges.
- Digital output: Plug and play feature enables ease of implementation and system level connectivity.
- Total Error Band: Provides true performance over the compensated temperature range, which minimizes the need to test and calibrate every sensor, thereby potentially reducing manufacturing cost; improves sensor accuracy and offers ease of sensor interchangeability due to minimal part-to-part variation. (See Figure 1.)

POTENTIAL APPLICATIONS

- Consumer medical: Non-invasive blood pressure monitoring, negative-pressure wound therapy, breast pumps, mobile oxygen concentrators, airflow monitors, CPAP water tanks, and medical wearables
- Non-consumer medical: Invasive blood pressure monitors, ambulatory blood pressure measurement
- Industrial: Air braking systems, gas and water meters
- Consumer: Coffee machines, humidifiers, air beds, washing machines, dishwashers

PORTFOLIO

The MPR Series joins an extensive line of board mount pressure sensors for potential use in medical, industrial, and consumer applications.

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Figure 1. TEB Components for the MPR Series

Total Error Band (TEB) is a single specification that includes the major sources of sensor error. TEB should not be confused with accuracy, which is actually a component of TEB. TEB is the worst error that the sensor could experience.

Honeywell uses the TEB specification in its datasheet because it is the most comprehensive measurement of a sensor's true accuracy. Honeywell also provides the accuracy specification in order to provide a common comparison with competitors' literature that does not use the TEB specification.

Many competitors do not use TEB—they simply specify the accuracy of their device. Their accuracy specification, however, may exclude certain parameters. On their datasheet, the errors are listed individually. When combined, the total error (or what would be TEB) could be significant.

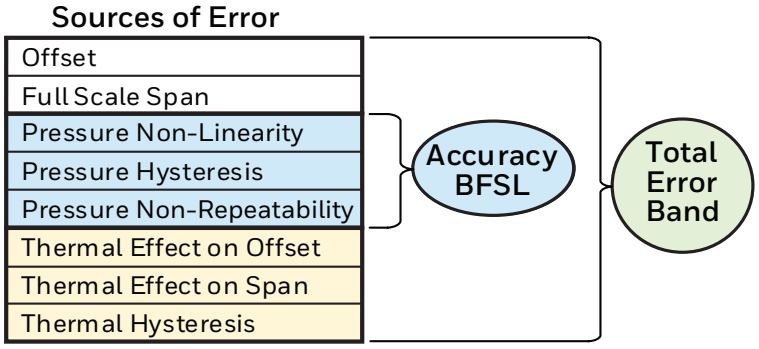


Table 1. Absolute Maximum Ratings[1]

Characteristic	Min.	Max.	Unit
Supply voltage (V_{supply})	-0.3	3.6	Vdc
Voltage on any pin	-0.3	V_{supply} + 0.3	V
ESD susceptibility (human body model)	—	4	kV
Storage temperature	-40 [-40]	85 [185]	°C [°F]
Soldering peak reflow temperature and time	15 s max. at 250°C [482°F]		

[1]Absolute maximum ratings are the extreme limits the device will withstand without damage.

Table 2. Environmental Specifications

Characteristic	Parameter
Humidity: external surfaces internal surfaces	 0 %RH to 95 %RH, non-condensing 0 %RH to 100 %RH, condensing
Vibration	10 g, 10 Hz to 2 kHz
Shock	50 g, 6 ms duration
Solder reflow	J-STD-020-D.1 Moisture Sensitivity Level 1 (unlimited shelf life when stored at ≤30°C/85 %RH)

Table 3. Wetted Materials

Component	Material
Port	304 stainless steel
Adhesives	epoxy
Electronic components	not exposed (protected by gel)

Table 4. Sensor Pressure Types

Pressure Type	Description
Absolute	Output is proportional to the difference between applied pressure and a built-in vacuum reference.
Gage	Output is proportional to the difference between applied pressure and atmospheric (ambient) pressure.

Table 5. Operating Specifications

Characteristic	Min.	Typ.	Max.	Unit
Supply voltage (V_{supply}):[1, 2]	1.8	3.3	3.6	Vdc
Supply current at 3.3 Vdc: standby mode active mode	 — —	 0.0005 1.7	 — —	mA
Power consumption	—	10	—	mW
Operating temperature range[3]	-40 [-40]	—	85 [185]	°C [°F]
Compensated temperature range[4]	0 [32]	—	50 [122]	°C [°F]
Startup time (power up to data ready)	—	—	2.5	ms
Data rate	—	200	—	samples per second
I^2C/SPI voltage level: low high	 — 80	 — —	 20 —	$\%V_{supply}$
Pull up on MISO, SCLK, SS, MOSI	1	—	—	kOhm
Accuracy[5]	—	—	±0.25	%FSS BFSL[6]
Resolution: transfer function A transfer function B transfer function C	 14.0 13.5 14.0	 — — —	 — — —	bits

[1]**Ratiometricity of the sensor (the ability of the device output to scale to the supply voltage):** Achieved within the specified operating voltage.

[2]The sensor is not reverse polarity protected. Incorrect application of supply voltage or ground to the wrong pin may cause electrical failure.

[3]**Operating temperature range:** The temperature range over which the sensor will produce an output proportional to pressure.

[4]**Compensated temperature range:** The temperature range over which the sensor will produce an output proportional to pressure within the specified performance limits (Total Error Band).

[5]**Accuracy:** The maximum deviation in output from a Best Fit Straight Line (BFSL) fitted to the output measured over the pressure range. Includes all errors due to pressure non-linearity, pressure hysteresis, and non-repeatability.

[6]**Full Scale Span (FSS):** The algebraic difference between the output signal measured at the maximum (Pmax.) and minimum (Pmin.) limits of the pressure range. (See Figure 2 for pressure ranges.)

Figure 2. Product Nomenclature

For example, **MPRLS0025PA00001A** defines an MPR Series pressure sensor, long port, silicone gel, 0 psi to 25 psi absolute pressure range, I²C, address 0x18, 10% to 90% of 2^{24} counts transfer function, no breakout board.

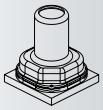
MPR L S 0025PA 0000 1 A

Product Series

MPR	

Pressure Port

L	Long



Gel

S	Silicone gel

Transfer Function[2]

A	10% to 90% of 2^{24} counts
B	2.5% to 22.5% of 2^{24} counts
C	20% to 80% of 2^{24} counts

Output Type

S	SPI	4	I²C, Address 0x48
0	I²C, Address 0x08	5	I²C, Address 0x58
1	I²C, Address 0x18	6	I²C, Address 0x68
2	I²C, Address 0x28	7	I²C, Address 0x78
3	I²C, Address 0x38		

Low Pressure

0000

Pressure Range, Unit and Reference[1]

Absolute		*Absolute*		*Absolute*	
0001BA	0 bar to 1 bar	**0100KA**	0 kPa to 100 kPa	**0015PA**	0 psi to 15 psi
01.6BA	0 bar to 1.6 bar	**0160KA**	0 kPa to 160 kPa	**0025PA**	0 psi to 25 psi
02.5BA	0 bar to 2.5 bar	**0250KA**	0 kPa to 250 kPa	**0030PA**	0 psi to 30 psi
Gage		*Gage*		*Gage*	
0060MG	0 mbar to 60 mbar	**0006KG**	0 kPa to 6 kPa	**0001PG**	0 psi to 1 psi
0100MG	0 mbar to 100 mbar	**0010KG**	0 kPa to 10 kPa	**0005PG**	0 psi to 5 psi
0160MG	0 mbar to 160 mbar	**0016KG**	0 kPa to 16 kPa	**0015PG**	0 psi to 15 psi
0250MG	0 mbar to 250 mbar	**0025KG**	0 kPa to 25 kPa	**0030PG**	0 psi to 30 psi
0400MG	0 bar to 400 mbar	**0040KG**	0 kPa to 40 kPa		
0600MG	0 bar to 600 mbar	**0060KG**	0 kPa to 60 kPa		
0001BG	0 bar to 1 bar	**0100KG**	0 kPa to 100 kPa		
01.6BG	0 bar to 1.6 bar	**0160KG**	0 kPa to 160 kPa		
02.5BG	0 bar to 2.5 bar	**0250KG**	0 kPa to 250 kPa		

Gage

0300YG	0 mmHg to 300 mmHg

N	inH_20
G	MPa
H	HPa
C	cmH_20

Other calibration units may be specified.

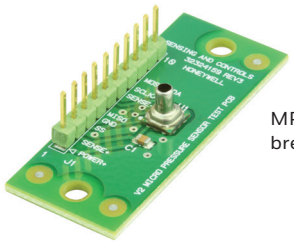
[1] The MPR Series is available in a number of configurations. Contact Honeywell or your authorized distributor for a current list of available configurations. For applications above 250,000 units per year, additional configurations are available.

[2] Transfer Function varies by Pressure Range selection, see Tables 6-8 for allowed values.

MPR Series Sensor Mounted on a Breakout Board

Breakout boards, designed for use with the Honeywell SEK002 Sensor Evaluation Kit, are available with the sensor already mounted.

Order using the catalog listings in the table below.



MPR Series mounted on a breakout board.

Catalog Listing	Description
MPRLS0025PA00001AB	Breakout board with 0 psi to 25 psi absolute sensor, long port, with gel, I²C = 0x18, transfer function A
MPRLS0015PA0000SAB	Breakout board with 0 psi to 15 psi absolute sensor, long port, with gel, SPI, transfer function A
MPRLS0001PG0000SAB	Breakout board with 0 psi to 1 psi gage sensor, long port, with gel, SPI, transfer function A
MPRLS0300YG00001BB	Breakout board with 0 mmHg to 300 mmHg gage sensor, long port, with gel, I²C = 0x18, transfer function B

Table 6. Pressure Range Specifications for 60 mbar to 2.5 bar

Pressure Range (See Figure 2.)	Pressure Range		Unit	Over Pressure[1]	Burst Pressure[2]	Total Error Band after Customer Auto-Zero[3] (%FSS)	Transfer Function
	Pmin.	Pmax.					
Absolute							
0001BA	0	1	bar	4	8	±1.5	A
01.6BA	0	1.6	bar	4	8	±1.5	A
02.5BA	0	2.5	bar	4	8	±1.5	A
Gage							
0060MG	0	60	mbar	350	700	±3.0	B
0100MG	0	100	mbar	350	700	±3.0	A
0160MG	0	160	mbar	350	700	±2.5	A
0250MG	0	250	mbar	350	700	±2.5	A
0400MG	0	400	mbar	4000	8000	±2.0	B
0600MG	0	600	mbar	4000	8000	±2.0	A
0001BG	0	1	bar	4	8	±1.5	A
01.6BG	0	1.6	bar	4	8	±1.5	A
02.5BG	0	2.5	bar	4	8	±1.5	A

[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. The customer's pressure connection system (tubing or O-rings) must be specified to be equal to, or greater than, the rated overpressure limit. Due to the possibility of light sensitivity, opaque tubing is recommended.

[2] **Burst Pressure:** The maximum pressure that may be applied to any port 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.

[3] **Total Error Band after Customer Auto-Zero:** The maximum deviation from the ideal transfer function over the entire compensated pressure range for a minimum of 24 hours after an auto-zero operation. Includes all errors due to full scale span, pressure non-linearity, pressure hysteresis, and thermal effect on span. Low pressure MPR sensors may exhibit offset shifts after reflow solder. See Technical Note "Auto-Zero Calibration Technique for Pressure Sensors" (008326-1-EN) if this shift is significant in a particular application.

Table 7. Pressure Range Specifications for 6 kPa to 250 kPa

Pressure Range (See Figure 2.)	Pressure Range		Unit	Over Pressure[1]	Burst Pressure[2]	Total Error Band after Customer Auto-Zero[3] (%FSS)	Transfer Function
	Pmin.	Pmax.					
Absolute							
0100KA	0	100	kPa	400	800	±1.5	A
0160KA	0	160	kPa	400	800	±1.5	A
0250KA	0	250	kPa	400	800	±1.5	A
Gage							
0006KG	0	6	kPa	35	70	±3.0	B
0010KG	0	10	kPa	35	70	±3.0	A
0016KG	0	16	kPa	35	70	±2.5	A
0025KG	0	25	kPa	35	70	±2.5	A
0040KG	0	40	kPa	400	800	±2.0	B
0060KG	0	60	kPa	400	800	±2.0	A
0100KG	0	100	kPa	400	800	±1.5	A
0160KG	0	160	kPa	400	800	±1.5	A
0250KG	0	250	kPa	400	800	±1.5	A

[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. The customer's pressure connection system (tubing or O-rings) must be specified to be equal to, or greater than, the rated overpressure limit. Due to the possibility of light sensitivity, opaque tubing is recommended.

[2] **Burst Pressure:** The maximum pressure that may be applied to any port 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.

[3] **Total Error Band after Customer Auto-Zero:** The maximum deviation from the ideal transfer function over the entire compensated pressure range for a minimum of 24 hours after an auto-zero operation. Includes all errors due to full scale span, pressure non-linearity, pressure hysteresis, and thermal effect on span. Low pressure MPR sensors may exhibit offset shifts after reflow solder. See Technical Note "Auto-Zero Calibration Technique for Pressure Sensors" (008326-1-EN) if this shift is significant in a particular application.

Table 8. Pressure Range Specifications for 1 psi to 30 psi

Pressure Range (See Figure 2.)	Pressure Range		Unit	Over Pressure[1]	Burst Pressure[2]	Total Error Band after Customer Auto-Zero[3] (%FSS)	Transfer Function
	Pmin.	Pmax.					
Absolute							
0015PA	0	15	psi	60	120	±1.5	A
0025PA	0	25	psi	60	120	±1.5	A
0030PA	0	30	psi	60	120	±1.5	A
Gage							
0001PG	0	1	psi	5	10	±3.0	A
0005PG	0	5	psi	60	120	±2.0	B
0015PG	0	15	psi	60	120	±1.5	A
0030PG	0	30	psi	60	120	±1.5	A

[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. The customer's pressure connection system (tubing or O-rings) must be specified to be equal to, or greater than, the rated overpressure limit. Due to the possibility of light sensitivity, opaque tubing is recommended.

[2] **Burst Pressure:** The maximum pressure that may be applied to any port 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.

[3] **Total Error Band after Customer Auto-Zero:** The maximum deviation from the ideal transfer function over the entire compensated pressure range for a minimum of 24 hours after an auto-zero operation. Includes all errors due to full scale span, pressure non-linearity, pressure hysteresis, and thermal effect on span. Low pressure MPR sensors may exhibit offset shifts after reflow solder. See Technical Note "Auto-Zero Calibration Technique for Pressure Sensors" (008326-1-EN) if this shift is significant in a particular application.

Table 9. Pressure Range Specifications for 0 mmHg to 300 mmHg

Pressure Range (See Figure 2.)	Pressure Range		Unit	Over Pressure[1]	Burst Pressure[2]	Total Error Band after Customer Auto-Zero[3] (%FSS)	Transfer Function
	Pmin.	Pmax.					
Gage							
0300YG	0	300	mmHg	3100	6200	±2.0	B

[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. The customer's pressure connection system (tubing or O-rings) must be specified to be equal to, or greater than, the rated overpressure limit. Due to the possibility of light sensitivity, opaque tubing is recommended.

[2] **Burst Pressure:** The maximum pressure that may be applied to any port 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.

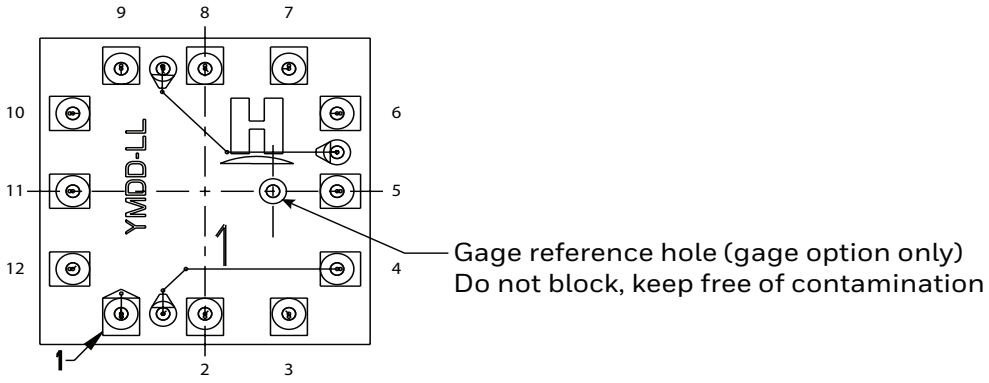
[3] **Total Error Band after Customer Auto-Zero:** The maximum deviation from the ideal transfer function over the entire compensated pressure range for a minimum of 24 hours after an auto-zero operation. Includes all errors due to full scale span, pressure non-linearity, pressure hysteresis, and thermal effect on span. Low pressure MPR sensors may exhibit offset shifts after reflow solder. See Technical Note "Auto-Zero Calibration Technique for Pressure Sensors" (008326-1-EN) if this shift is significant in a particular application.

1.0 General Information

Please see pages 17-19 for product dimensions, pinouts, tape and reel dimensions, Recommended Pick and Place Geometry, and recommended tubing.

2.0 Pinout and Functionality (See Table 10.)

Table 10. Pinout and Functionality



Pad Number	Name	Description
1	SS	Slave Select: Chip select for SPI sensor
2	MOSI/SDA	Master Out Slave In: Data in for SPI sensor; data in/out for I²C sensor
3	SCLK/SCL	Clock input for SPI and I²C sensor
4	VO+	V_{OUT+} pin in piezoresistive Wheatstone Bridge: Anti-aliasing filter can be connected between VO+ and VO-
5	NC	No connection
6	VO-	V_{OUT-} pin in piezoresistive Wheatstone Bridge: Anti-aliasing filter can be connected between VO- and VO+
7	MISO	Master In Slave Out: Data output for SPI sensor
8	EOC	End-of-conversion indicator: This pin is set high when a measurement and calculation have been completed and the data is ready to be clocked out
9	RES	Reset: This pin can be connected and used to control safe resetting of the sensor. RES is active-low; a V_{DD}-V_{SS}-V_{DD} transition at the RES pin leads to a complete sensor reset
10	V_{SS}	Ground reference voltage signal
11	NC	No connection
12	V_{DD}	Positive supply voltage

3.0 Start-Up Timing

On power-up, the MPR Series sensor is able to receive the first command after 1 ms from when the V_{DD} supply is within operating specifications. The MPR Series sensor can begin the first measurement after 2.5 ms from when the V_{DD} supply is operational. Alternatively, instead of a power-on reset, a reset and new power-up sequence can be triggered by an IC-reset signal (high low) at the RES pin.

4.0 Power Supply Requirement

Verify that system power to the sensor meets the V_{DD} rising slope requirement (minimum V_{DD} rising slope is at least 10 V/ms). If not, use the RES pin to bring the sensor out of reset once the system power has stabilized.

5.0 Reference Circuit Design

5.1 I²C and SPI Circuit Diagrams (Ssee Figures 3 and 4.)

Figure 3. I²C Circuit Diagram

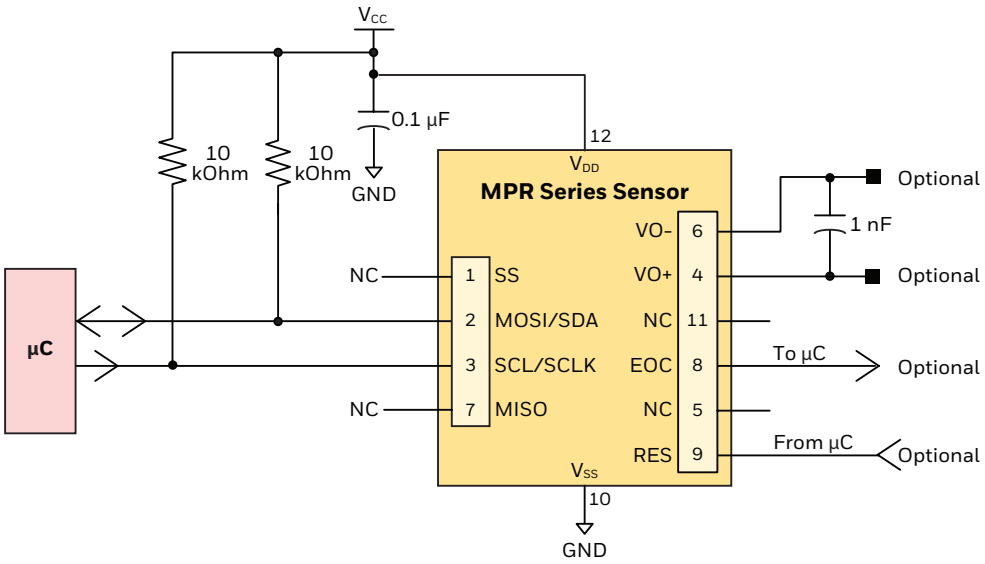
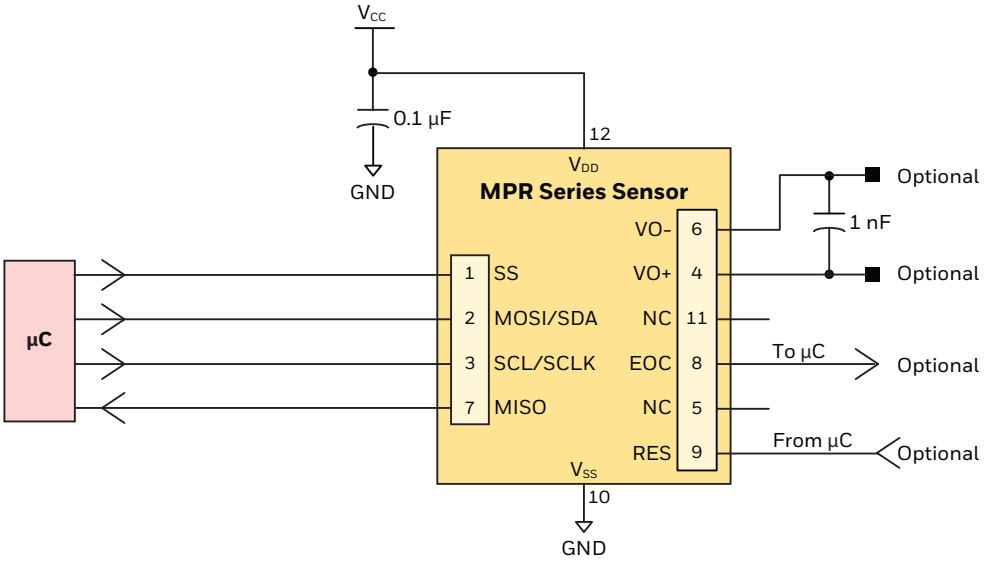


Figure 4. SPI Circuit Diagram



5.2 Bypass Capacitor Use

NOTICE

Ensure bypass capacitors are integrated into the end user design to ensure output noise supression.

6.0 I²C Communications

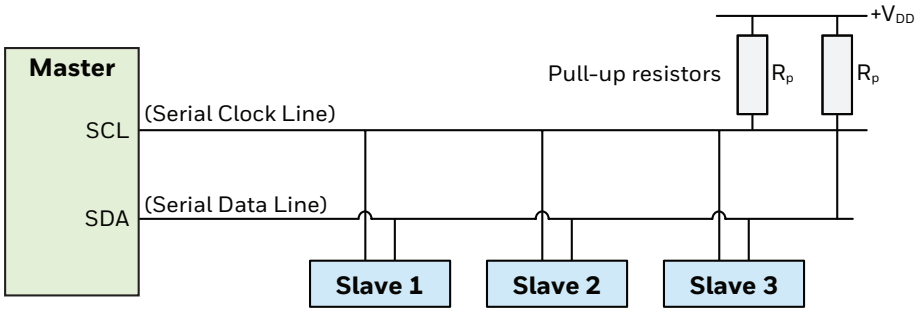
6.1 I²C Bus Configuration (See Figure 5.)

The I²C bus is a simple, serial 8-bit oriented computer bus for efficient I²C (Inter-IC) control. It provides good support for communication between different ICs across short circuit-board distances, such as interfacing microcontrollers with various low speed peripheral devices. For detailed specifications of the I²C protocol, see Version 2.1 (January 2000) of the I²C Bus Specification (source: NXP Semiconductor at https://www.nxp.com/docs/en/user-guide/UM10204.pdf).

Each device connected to the bus is software addressable by a unique address and a simple Master/Slave relationship that exists at all times. The output stages of devices connected to the bus are designed around an open collector architecture. Because of this, pull-up resistors to $+V_{DD}$ must be provided on the bus. Both SDA and SCL are bidirectional lines, and it is important to system performance to match the capacitive loads on both lines. In addition, in accordance with the I²C specification, the maximum allowable capacitance on either line is 400 pF to ensure reliable edge transitions at 400 kHz clock speeds.

When the bus is free, both lines are pulled up to $+V_{DD}$. Data on the I²C bus can be transferred at a rate up to 100 kbit/s in the standard-mode, or up to 400 kbit/s in the fast-mode.

Figure 5. I²C Bus Configuration



6.2 I²C Data Transfer

The MPR Series I²C sensors are designed to work as Slaves and will therefore only respond to requests from a Master device. Following the address and read bit from the Master, the MPR Series sensors are designed to output up to 4 bytes of data. The first data byte is the Status Byte (8-bit) and the second to fourth bytes are the compensated pressure output (24-bit).

6.3 I²C Sensor Address

Each MPR Series I²C sensor is referenced on the bus by a 7-bit slave address. The default address for the MPR Series is 24 (0x18). Other available standard addresses are: 08 (0x08), 40 (0x28), 56 (0x38), 72 (0x48), 88 (0x58), 104 (0x68), 120 (0x78). (Other custom values are available. Please contact Honeywell Customer Service with questions regarding custom Slave addresses.)

6.4 I²C Pressure Reading

To read out a compensated pressure reading, the Master generates a START condition and sends the sensor Slave address followed by a read bit (1). After the sensor generates an acknowledge, it will transmit up to 4 bytes of data. The first data byte is the Status Byte (8-bit) and the second to fourth bytes are the compensated pressure output (24-bit). The Master must acknowledge the receipt of each byte, and can terminate the communication by sending a Not Acknowledge (NACK) bit followed by a Stop bit after receiving the required bytes of data.

6.5 I²C Status Byte (See Table 11.)

Table 11. I²C Status Byte Explanation

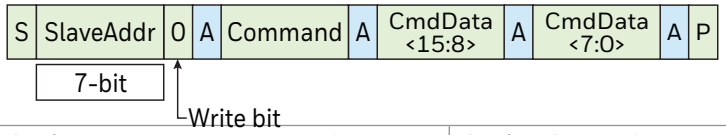
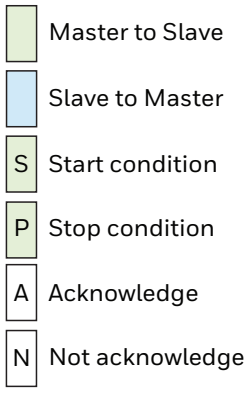
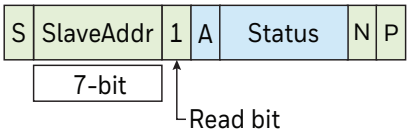
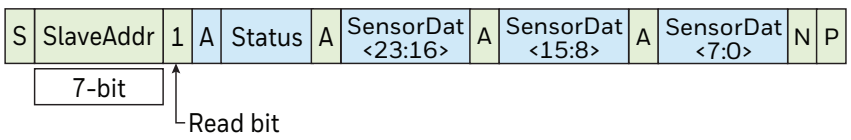
Bit (Meaning)	Status	Comment
7	always 0	—
6 (Power indication)	1 = device is powered 0 = device is not powered	Needed for the SPI Mode where the Master reads all zeroes if the device is not powered or in power-on reset (POR).
5 (Busy flag)	1 = device is busy,	Indicates that the data for the last command is not yet available. No new commands are processed if the device is busy.
4	always 0	—
3	always 0	—
2 (Memory integrity/error flag)	0 = integrity test passed 1 = integrity test failed	Indicates whether the checksum-based integrity check passed or failed; the memory error status bit is calculated only during the power-up sequence.
1	always 0	—
0 (Math saturation)	1 = internal math saturation has occurred	—

6.6 I²C Communications

6.6.1 I²C Output Measurement Command

To communicate with the MPR Series I²C output sensor using an Output Measurement Command of “0xAA”, followed by “0x00” “0x00”, follow the steps shown in Table 12.

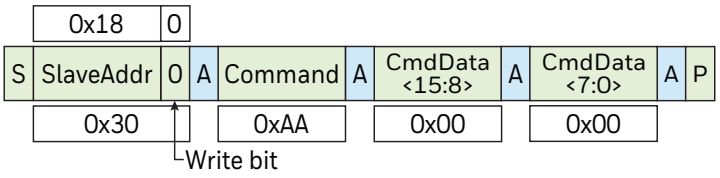
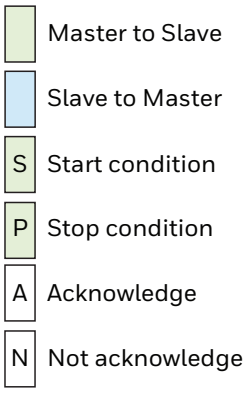
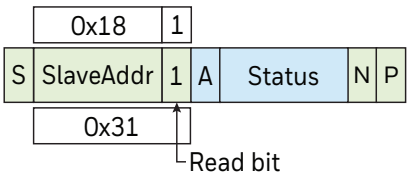
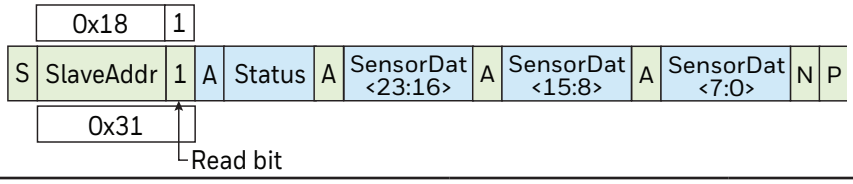
Table 12. I²C Output Measurement Command

Step	Action	Notes
1		
2	**Option 1:** Wait until the busy flag in the Status Byte clears.  **Option 2:** Wait for at least 5 ms for the data conversion to occur. **Option 3:** Wait for the EOC indicator.	
3	To read the 24-bit pressure output along with the 8-bit Status Byte 	

6.6.2 I²C Slave Address of 0x18

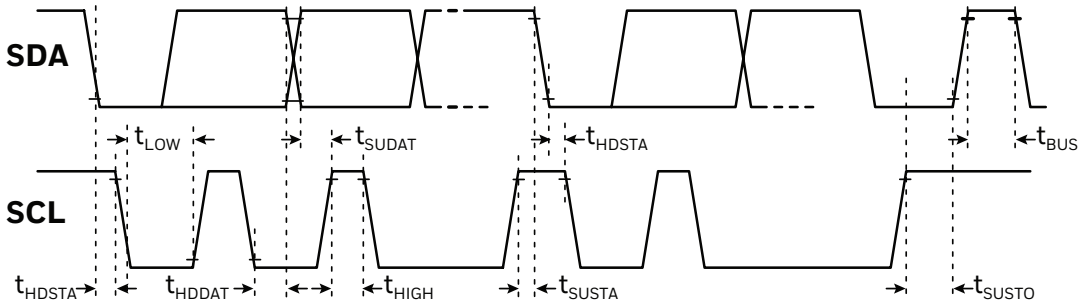
To communicate with the MPR Series I²C output sensor with an I²C Slave Address of 0x18 (hex), follow the steps shown in Table 13.

Table 13. I²C Slave Address of 0x18 Communications

Step	Action	Notes
1		
2	**Option 1:** Wait until the busy flag in the Status Byte clears.  **Option 2:** Wait for at least 5 ms for the data conversion to occur. **Option 3:** Wait for the EOC indicator.	
3	To read the 24-bit pressure output along with the 8-bit Status Byte: 	

6.7 I²C Timing and Level Parameters (See Table 14.)

Table 14. I²C Bus Timing Diagram and Parameters



Characteristic	Abbreviation	Min.	Typ.	Max.	Unit
SCLK clock frequency	f_{SCL}	100	—	400	kHz
Start condition hold time relative to SCL edge	t_{HDSTA}	0.1	—	—	µs
Minimum SCLK clock low width[1]	t_{LOW}	0.6	—	—	µs
Minimum SCLK clock high width[1]	t_{HIGH}	0.6	—	—	µs
Start condition setup time relative to SCL edge	t_{SUSTA}	0.1	—	—	µs
Data hold time on SDA relative to SCL edge	t_{HDDAT}	0	—	—	µs
Data setup time on SDA relative to SCL edge	t_{SUDAT}	0.1	—	—	µs
Stop condition setup time on SCL	t_{SUSTO}	0.1	—	—	µs
Bus free time between stop condition and start condition	t_{BUS}	2	—	—	µs
Output level low	Out_{low}	—	0	0.2	V_{DD}
Output level high	Out_{high}	0.8	1	—	V_{DD}
Pull-up resistance on SDA and SCL	R_p	1	—	50	kOhm

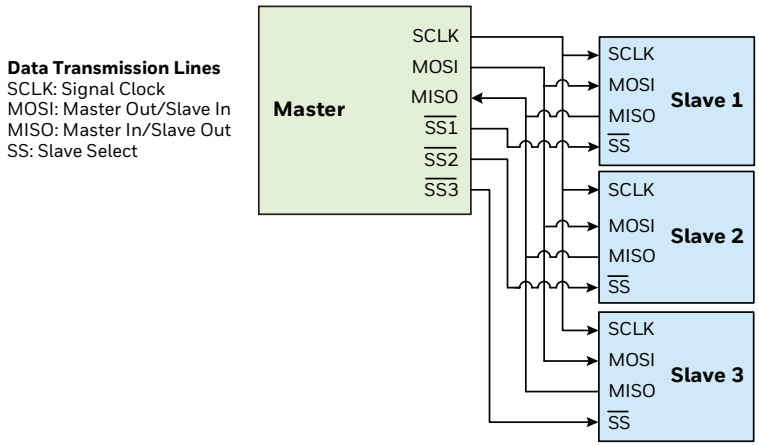
[1]Combined low and high widths must equal or exceed minimum SCLK period.

7.0 SPI Communications

7.1 SPI Definition

The Serial Peripheral Interface (SPI) is a simple bus system for synchronous serial communication between one Master and one or more Slaves. It operates either in full-duplex or half-duplex mode, allowing communication to occur in either both directions simultaneously, or in one direction only. The Master device initiates an information transfer on the bus and generates clock and control signals. Slave devices are controlled by the Master through individual Slave Select (SS) lines and are active only when selected. The MPR Series SPI sensors operate in full-duplex mode only, with data transfer from the Slave to the Master. This data transmission uses four, unidirectional bus lines. The Master controls SCLK, MOSI and SS; the Slave controls MISO. (See Figure 6.)

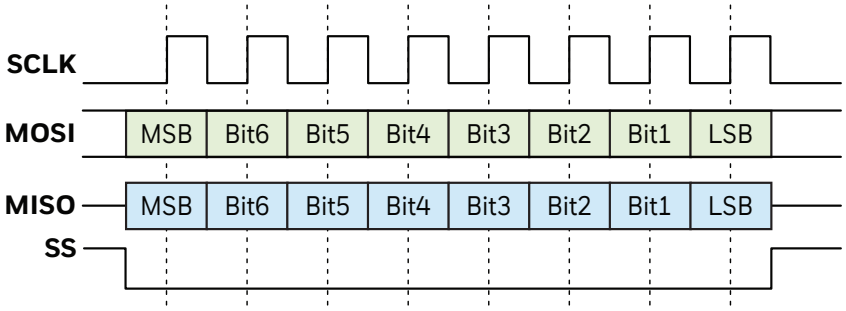
Figure 6. SPI Bus Configuration



7.2 SPI Data Transfer

Starting communication with the MPR Series SPI sensors begins by de-asserting the Slave Select (SS) line. At this point, the sensor is no longer idle, and will begin sending data once a clock is received. MPR Series SPI sensors are configured for SPI operation in mode 0 (clock polarity is 0 and clock phase is 0). (See Figure 7.)

Figure 7. Example of 1 Byte SPI Data Transfer



Once the clocking begins, the MPR Series SPI sensor is designed to output up to 4 bytes of data. The first data byte is the Status Byte (8-bit) and the second to fourth bytes are the compensated pressure output (24-bit).

7.3 SPI Pressure Reading

To read out a compensated pressure reading, the Master generates the necessary clock signal after activating the sensor with the Slave Select (SS) line. The sensor will transmit up to 4 bytes of data. The first data byte is the Status Byte (8-bit) and the second to fourth bytes are the compensated pressure output (24-bit). The Master can terminate the communication by stopping the clock and deactivating the SS line.

7.4 SPI Status Byte

The SPI status byte contains the bits shown in Table 14.

7.5 SPI Communication

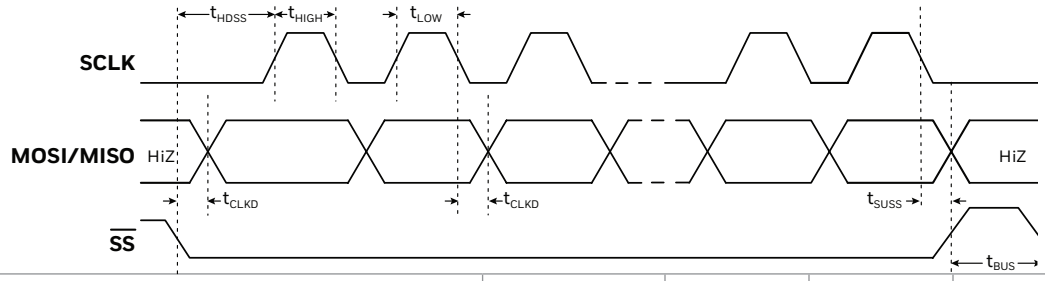
To communicate with the MPR Series SPI output sensor using an Output Measurement Command of "0xAA", followed by "0x00" "0x00", follow the steps shown in Table 15.

Table 15. SPI Output Measurement Command

Step	Action	Notes
1	The data on MISO depend on the preceding command. Discard the data on the MISO line. **MOSI**: 0xAA | 0x00 | 0x00 / Command other than NOP | CmdData <15:8> | CmdData <7:0> **MISO**: Status | Data | Data	Master to Slave Slave to Master • NOP Command is "0xF0".
2	**Option 1:** Wait until the busy flag in the Status Byte clears. **MOSI**: 0xF0 / Command = NOP **MISO**: Status **Option 2:** Wait for at least 5 ms for the data conversion to occur. **Option 3:** Wait for the EOC indicator.	
3	To read the 24-bit pressure output along with the 8-bit Status Byte: **MOSI**: 0xF0 | 0x00 | 0x00 | 0x00 / Command = NOP | 00_{Hex} | 00_{Hex} | 00_{Hex} **MISO**: Status | SensorDat <24:16> | SensorDat <15:8> | SensorDat <7:0>	

7.6 SPI Timing and Level Parameters (See Table 16.)

Table 16. SPI Bus Timing Diagram and Parameters



Characteristic	Abbreviation	Min.	Typ.	Max.	Unit
SCLK clock frequency	f_{SCL}	50	—	800	kHz
SS drop to first clock edge	t_{HDSS}	2.5	—	—	µs
Minimum SCLK clock low width[1]	t_{LOW}	0.6	—	—	µs
Minimum SCLK clock high width[1]	t_{HIGH}	0.6	—	—	µs
Clock edge to data transition	t_{CLKD}	0	—	—	µs
Rise of SS relative to last clock edge	t_{SUSS}	0.1	—	—	µs
Bus free time between rise and fall of SS	t_{BUS}	2	—	—	µs
Output level low	Out_{low}	—	0	0.2	V_{DD}
Output level high	Out_{high}	0.8	1	—	V_{DD}

[1]Combined low and high widths must equal or exceed minimum SCLK period.

8.0 MPR Series Sensor Output Pressure Calculation

The MPR Series sensor output can be expressed by the transfer function of the device as shown in Equation 1:

Equation 1: Pressure Sensor Transfer Function

$$\text{Output} = \frac{\text{Output}_{max.} - \text{Output}_{min.}}{P_{max.} - P_{min.}} * (\text{Pressure} - P_{min.}) + \text{Output}_{min.}$$

Rearranging this equation to solve for Pressure, we get Equation 2:

Equation 2: Pressure Output Function

$$\text{Pressure} = \frac{(\text{Output} - \text{Output}_{min.}) * (P_{max.} - P_{min.})}{\text{Output}_{max.} - \text{Output}_{min.}} + P_{min.}$$

Where:

$\text{Output}_{max.}$ = output at maximum pressure [counts]
$\text{Output}_{min.}$ = output at minimum pressure [counts]
$P_{max.}$ = maximum value of pressure range [bar, psi, kPa, etc.]
$P_{min.}$ = minimum value of pressure range [bar, psi, kPa, etc.]
Pressure = pressure reading [bar, psi, kPa, etc.]
Output = digital pressure reading [counts]

Example: Calculate the pressure for a -1 psi to 1 psi gage sensor with a 10% to 90% calibration, and a pressure output of 14260634 (decimal) counts:

$\text{Output}_{max.}$ = 15099494 counts (90% of 2^{24} counts or 0xE66666)
$\text{Output}_{min.}$ = 1677722 counts (10% of 2^{24} counts or 0x19999A)
$P_{max.}$ = 1 psi
$P_{min.}$ = -1 psi
Pressure = pressure in psi
Output = 14260634 counts

$$\text{Pressure} = \left[\frac{(14260634-1677722) * (1 - (- 1))}{15099494 - 1677722}\right] + (-1)$$

$$\text{Pressure} = \frac{25165824}{13421772} + (-1)$$

$$\text{Pressure} = 0.875 \text{ psi}$$

Figure 8. Product Dimensions (For reference only: mm [in].)

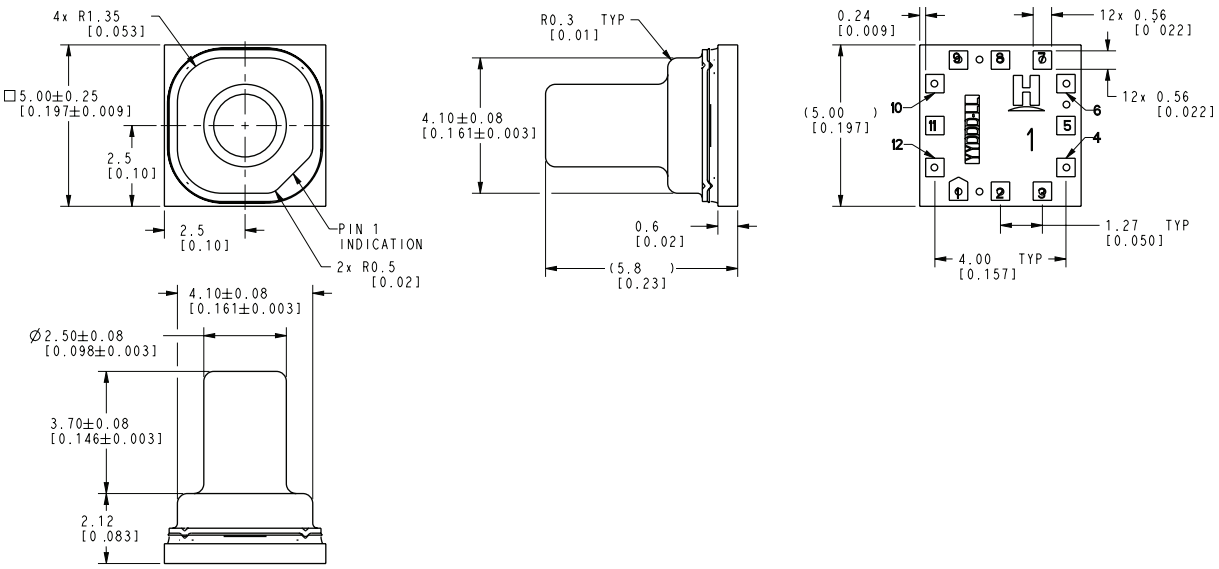
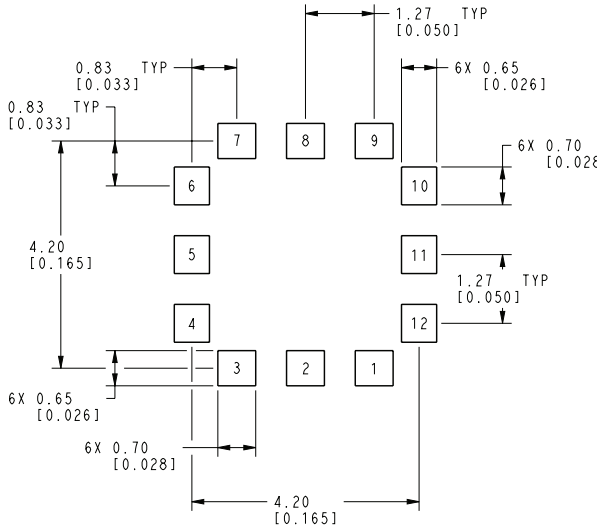


Figure 9. Recommended PCB Pad Layout

Absolute



Gage

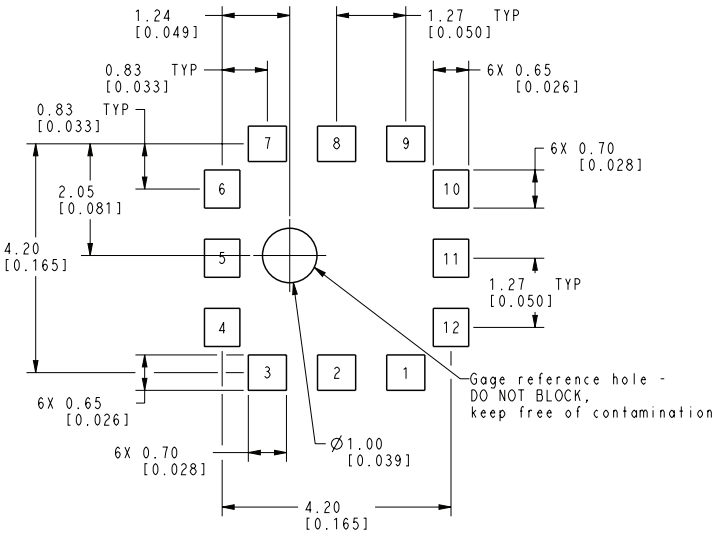
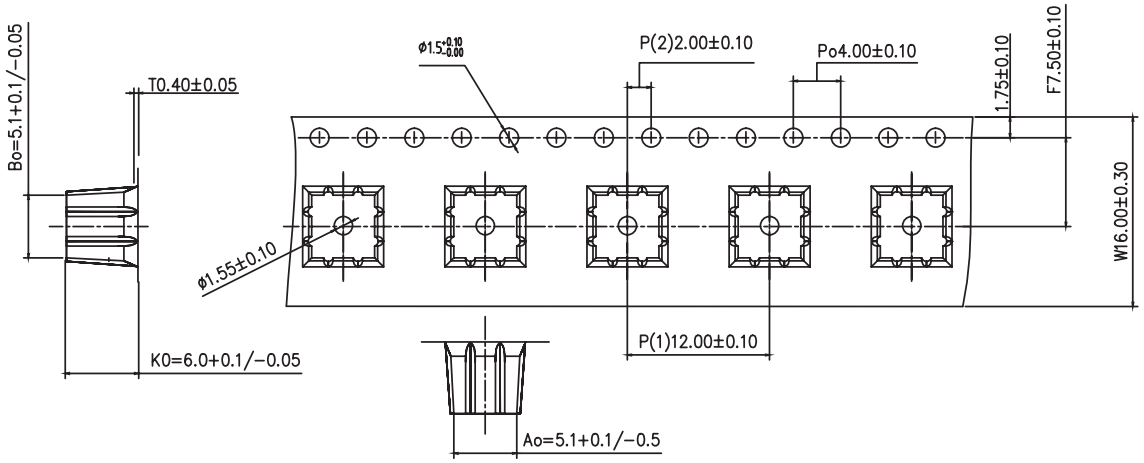


Figure 10. Product Tape and Reel Dimensions (For reference only: mm.)

Tape



Reel

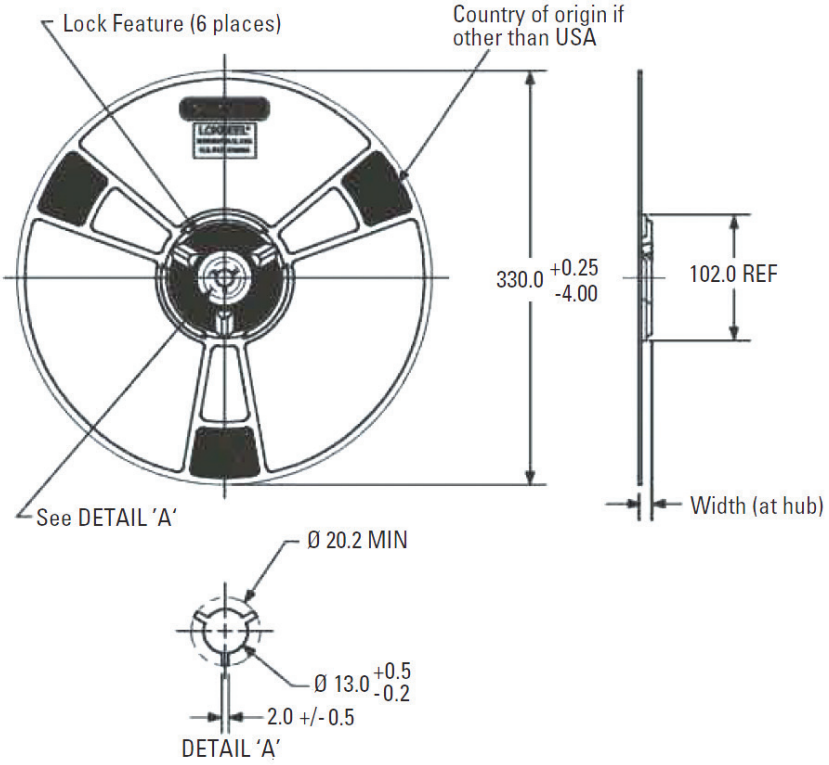


Figure 11. Recommended Pick and Place Geometry (Used with permission of Micro-Mechanics Pte Ltd.)

Micro-Mechanics part number: 19-EP-10267-02

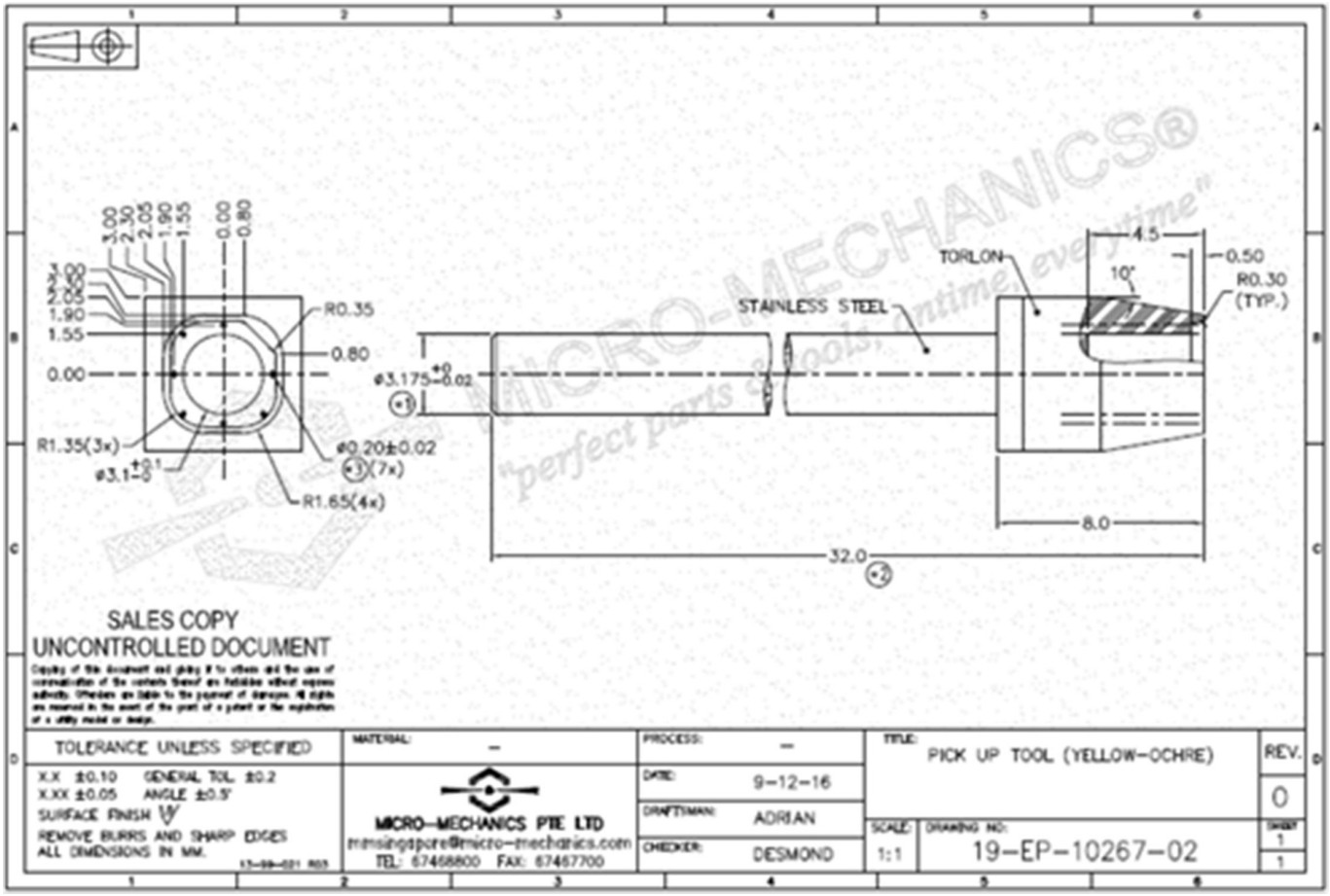


Table 17. Recommended Tubing

Manufacturer	Type	Part Number	ID (in)	OD (in)	Pressure at 25°C (psi)
Frelin-Wade	Fre-Thane® (polyurethane)	1A-156-11	0.093	0.156	210
Frelin-Wade	nylon	1A-200-01	0.093	0.125	270
NewAge Industries	PVC	1100225	0.094	0.156	42
NewAge Industries	silicone	2800315	0.094	0.156	20

ADDITIONAL INFORMATION

The following associated literature is available on sensing.honeywell.com:

- Product line guide
- Product range guide
- Application information
- CAD models
- Product images

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