# Honeywell

# **TruStability™ Board Mount Pressure Sensors**

RSC Series—High Resolution, High Accuracy, Compensated  $\pm 1.6$  mbar to  $\pm 10$  bar |  $\pm 160$  Pa to  $\pm 1$  MPa |  $\pm 0.5$  inH<sub>2</sub>O to  $\pm 150$  psi 24-bit Digital SPI-Compatible Output

**32321348** Issue E

Datasheet

## DESCRIPTION

The RSC Series is a 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 temperature compensated for sensor offset, sensitivity, temperature effects, and non-linearity using a 24-bit analog-to-digital converter with integrated EEPROM. Pressure data may be acquired at rates between 20 and 2000 samples per second over an SPI interface. It is intended for use with non-corrosive, non-ionic gases, such as air and other dry gases, designed and manufactured according to ISO 9001 standards, and is REACH and RoHS compliant.

## VALUE TO CUSTOMERS

- Enhances performance: Output accelerates performance through reduced conversion requirements and direct interface to microprocessors. Proprietary Honeywell technology combines high sensitivity with high burst and over pressure while providing industry leading stability (performance factors difficult to achieve in the same sensor), providing flexibility in implementation and minimizing requirements for protecting the sensor without sacrificing ability to sense very small changes in pressure.
- Cost-effective, high volume solution with a variety of options.
- Enhances reliability: High burst pressures promote system reliability, minimize downtime, and can simplify design. High working pressures allow ultra-low sensors to be used continuously above the calibrated pressure range.
  Easy to design in: Package is small when compared to many
- Easy to design in: Package is small when compared to many similar sensors, occupying less area on the PCB. Port and housing options simplify integration. Wide pressure range simplifies use.
- 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 would 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.
- Energy efficient: Reduces system power requirements and enables extended battery life.

#### FEATURES

- Pressure range: ±1.6 mbar to ±10 bar | ±160 Pa to ±1 MPa | ±0.5 inH<sub>2</sub>O to ±150 psi; absolute range 1 bar to 8 bar | 15 psi to 150 psi
- Pressure types: Absolute: internal vacuum reference and an output value proportional to absolute pressure; Gage: referenced to atmospheric pressure and provide an output proportional to pressure variations from atmosphere; Differential: allows measurement of pressure between the two pressure ports
- Total Error Band: As low as ±0.25 %FSS depending on pressure range (after auto zero)
- Accuracy: ±0.1 %FSS BFSL (Full Scale Span Best Fit Straight Line)
- Compensated temperature range: -40°C to 85°C [-40°F to 185°F]
- Power consumption: Less than 10 mW, typ.
- Size: Miniature 10 mm x 12,5 mm [0.39 in x 0.49 in] package
- Output: 24-bit digital SPI-compatible
- Meets IPC/JEDEC J-STD-020D.1 Moisture Sensitivity Level 1 requirements

## DIFFERENTIATION

- Industry-leading long-term stability: Minimizes system calibration needs and significantly reduces downtime.
- Industry-leading accuracy: Reduces software to correct system inaccuracies, which minimizes design time, helps improve efficiency, and often simplifies development.
- Industry-leading flexibility: Modular design with many package styles and options simplify integration.
- Total Error Band: Provides true performance over the compensated temperature range, which eliminates the need to test and calibrate every sensor, thereby reducing manufacturing cost. Improves system accuracy and offers ease of sensor interchangeability due to minimal part-to-part variation (see Figure 1 on page 3).

## POTENTIAL APPLICATIONS

- Medical: Airflow monitors, anesthesia machines, blood analysis machines, gas chromatography, gas flow instrumentation, hospital room air pressure, kidney dialysis machines, nebulizers, pneumatic controls, respiratory machines, sleep apnea equipment, spirometers, ventilators
- Industrial: Barometry, drones, flow calibrators, gas chromatography, gas flow instrumentation, HVAC clogged filter detection, HVAC systems, HVAC transmitters, indoor air quality, life sciences, pneumatic control, VAV (Variable Air Volume) control, weather balloons

## PORTFOLIO

Honeywell offers a variety of board mount pressure sensors for potential use in medical and industrial applications. Our categories of pressure sensor measurement include absolute, differential, gage or vacuum gage, with unamplified or amplified sensors and covering a wide pressure range.

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# TruStability<sup>™</sup> Board Mount Pressure Sensors RSC Series

## Figure 1. TEB Components for TruStability<sup>™</sup> Board Mount Pressure Sensors

## All Possible Errors Offset Full Scale Span Pressure Non-Linearity Pressure Hysteresis Pressure Non-Repeatability Thermal Effect on Offset Thermal Effect on Span Thermal Hysteresis

#### Table 1. Absolute Maximum Ratings<sup>1</sup>

Characteristic	Min.	Max.	Unit	
Supply voltage (V <sub>supply</sub> )	2.7	6.0	Vdc	
Voltage on any pin	-0.3	V <sub>supply</sub> + 0.3	V	
Digital interface clock frequency	_	5	MHz	
ESD susceptibility (human body model)	_	2	kV	
Storage temperature	-40 [-40]	85 [185]	°C [°F]	
Soldering time and temperature: lead solder temperature (DIP) peak reflow temperature (SMT)		4 s max. at 250°C [482°F] 15 s max. at 250°C [482°F]		

<sup>1</sup>Absolute maximum ratings are the extreme limits the device will withstand without damage.

#### **Table 2. Environmental Specifications**

Characteristic	Parameter
Humidity (gases only)	0% to 95% RH, non-condensing
Vibration	15 g, 10 Hz to 2 Hz
Shock	100 g, 6 ms duration
Life <sup>1</sup>	1 million pressure cycles minimum
Solder reflow	J-STD-020-D.1 Moisture Sensitivity Level 1 (unlimited shelf life when stored at ≤30°C/85 % RH)

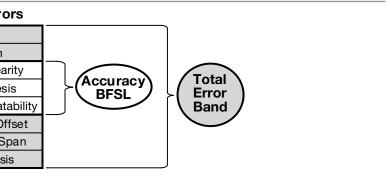
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#### Table 3. Wetted Materials<sup>1</sup>

Component	Port 1 (Pressure Port)	Port 2 (Reference Port)		
Ports and covers	high temperature polyamide	high temperature polyamide		
Substrate	alumina ceramic	alumina ceramic		
Adhesives	epoxy, silicone	epoxy, silicone		
Electronic components	plastic, silicon, glass, solder	silicon, glass, gold		

#### Table 4. Sensor Pressure Types

Pressure Type	
Absolute	Output is proportional to the difference
Differential	Output is proportional to the difference
Gage	Output is proportional to the difference



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nce between applied pressure and a built-in vacuum reference.

nce between the pressures applied to each port (Port 1 – Port 2).

## **TruStability™ Board Mount Pressure Sensors RSC** Series

**Table 5. Digital Operating Specifications** 

Characteristic	Min.	Тур.	Max.	Unit
Supply voltage (V <sub>supply</sub> ): <sup>1,2,3</sup> pressure ranges ≥60 mbar   6 kPa   1 psi: 3.3 Vdc 5.0 Vdc pressure ranges ≤40 mbar   4 kPa   20 inH <sub>2</sub> 0: 3.3 Vdc 5.0 Vdc	3.0 4.75 3.27 4.95	3.3 5.0 3.3 5.0	3.6 5.25 3.33 5.05	Vdc
Supply current: 3.3 Vdc: standby mode active mode 5.0 Vdc: standby mode active mode	_ _ _ _	1.3 1.7 2.1 2.6	_ _ _ _	mA
Operating temperature range <sup>4</sup>	-40 [-40]	_	85 [185]	°C [°F]
Compensated temperature range: <sup>5</sup> medical industrial extended	0 [32] -20 [-4] -40 [-40]		50 [122] 85 [185] 85 [185]	°C [°F]
Startup time (power up to data ready)	_	_	0.3	ms
Data rate	20, 40, 45, 9	samples per second		
SPI voltage level: low high	_ 80		20	%Vsupply
Pull up on MISO, SCLK, CS_ADC, CS_EE, MOSI	1	-	_	kOhm
Accuracy <sup>6</sup>	_	_	0.1	%FSS BFSL <sup>6</sup>
Orientation sensitivity (±1 g): <sup>7.9</sup> pressure ranges $\leq$ 40 mbar   4 kPa   20 inH <sub>2</sub> 0 pressure ranges $\leq$ 2.5 mbar   250 Pa   1 inH <sub>2</sub> 0		±0.1 ±0.2		%FSS <sup>8</sup>

<sup>1</sup>Sensors are either 3.3 Vdc or 5.0 Vdc based on the catalog listing selected.

<sup>2</sup>Ratiometricity of the sensor (the ability of the device output to scale to the supply voltage) is achieved within the specified operating voltage.

<sup>3</sup>The sensor is not reverse polarity protected. Incorrect application of supply voltage or ground to the wrong pin may cause electrical failure.

<sup>4</sup>Operating temperature range: The temperature range over which the sensor will produce an output proportional to pressure.

<sup>5</sup>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).

<sup>6</sup>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.

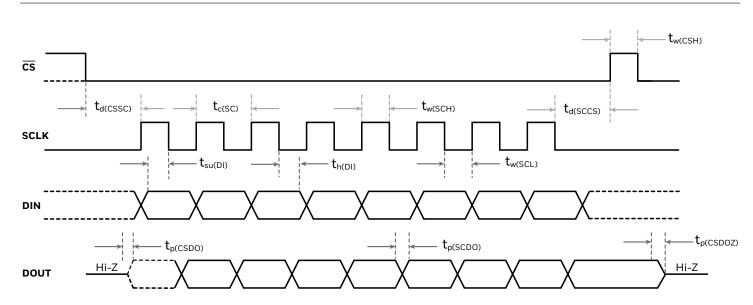
<sup>7</sup>Orientation sensitivity: The maximum change in offset of the sensor due to a change in position or orientation relative to Earth's gravitational field. <sup>8</sup>Full Scale Span (FSS). The algebraic difference between the output signal measured at the maximum (Pmax.) and minimum (Pmin.) limits of the pressure range. (See Figure 1 for ranges.)

 $^{9}$ Insignificant for pressure ranges above 40 mbar | 4 kPa | 20 inH $_{2}$ O.

# **TruStability™ Board Mount Pressure Sensors**

**RSC** Series



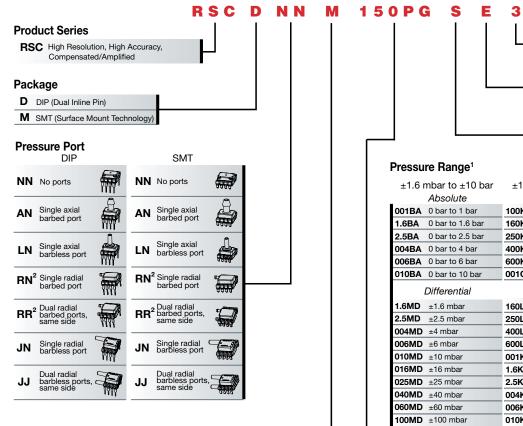


Characteristic	Description	Min.	Max.	Unit
t <sub>d(CSSC)</sub>	delay time; $\overline{\text{CS}}$ falling edge to first SCLK rising edge	50	_	ns
t <sub>d(SCCS)</sub>	delay time,;final SCLK falling edge to $\overline{\text{CS}}$ rising edge	30	_	ns
t <sub>w(CSH)</sub>	pulse duration; $\overline{CS}$ high	80	_	ns
t <sub>c(SC)</sub>	SCLK period	150	_	ns
t <sub>w(SCH)</sub>	pulse duration; SCLK high	75	_	ns
t <sub>w(SCL)</sub>	pulse duration; SCLK low	75	_	ns
t <sub>su(DI)</sub>	setup time; DIN valid before SCLK falling edge	50	—	ns
t <sub>h(DI)</sub>	hold time; DIN valid after SCLK falling edge	25	_	ns
t <sub>p(CSDO)</sub>	propagation delay time; $\overline{\text{CS}}$ falling edge to DOUT driven	_	50	ns
t <sub>p(SCDO)</sub>	propagation delay time; SCLK rising edge to valid new DOUT	0	50	ns
t <sub>p(CSDOZ)</sub>	propagation delay time; $\overline{\text{CS}}$ rising edge to DOUT high impedance	_	50	ns

<sup>1</sup>Single byte communication is shown. Actual communication may be several bytes.

#### Figure 3. Nomenclature and Order Guide

For example, RSCDNNM150PGSE3 defines an RSC Series TruStability™ Pressure Sensor, DIP package, NN pressure port, medical compensated temperature range, 150 psi gage pressure range, SPI output type, external math transfer function, 3.3 Vdc supply voltage.



#### Compensated Temperature Range<sup>1</sup>

М	Medical (0°C to 50°C [32°F to 122°F])	
T	Industrial (-20°C to 85°C [-4°F to 185°F])	
Е	Extended (-40°C to 85°C [-40°F to 185°F])	

<sup>1</sup>Custom pressure and temperature ranges are available. Contact Honeywell Customer Service for more information. <sup>2</sup>RR and RN pressure ports: The maximum applied pressure is 60 psi.

) P (	À S E	3			Supply Voltage
					3 3.3 Vdc
					5 5.0 Vdc
				т.	ansfer Function
				ĭ	
					Output Type
					S SPI
					-
ressu	re Range <sup>1</sup>				
	nbar to ±10 bar	+160	Pa to ±1 MPa	+0 5 ir	nH₂O to ±150 psi
1.01	Absolute	100	Absolute	10.0 1	Absolute
001BA	0 bar to 1 bar	100KA	0 kPa to 100 kPa	015PA	0 psi to 15 psi
1.6BA	0 bar to 1.6 bar	160KA	0 kPa to 160 kPa	030PA	0 psi to 30 psi
	0 bar to 2.5 bar		0 kPa to 250 kPa		0 psi to 60 psi
	0 bar to 4 bar		0 kPa to 400 kPa		0 psi to 100 psi
	0 bar to 6 bar 0 bar to 10 bar		0 kPa to 600 kPa 0 kPa to 1 MPa	ISUPA	0 psi to 150 psi
					Differential
			Differential		Differential
	±1.6 mbar ±2.5 mbar		±160 Pa ±250 Pa		±0.5 inH <sub>2</sub> O ±1 inH <sub>2</sub> O
	±4 mbar		±230 Pa		±2 inH <sub>2</sub> O
	±6 mbar		±600 Pa		±4 inH <sub>2</sub> O
010MD	±10 mbar	001KD	±1 kPa	005ND	±5 inH <sub>2</sub> O
016MD	±16 mbar	1.6KD	±1.6 kPa	010ND	±10 inH <sub>2</sub> O
	±25 mbar		±2.5 kPa		±20 inH₂O
	±40 mbar	004KD			±30 inH <sub>2</sub> O
	±60 mbar ±100 mbar	006KD	±6 kPa ±10 kPa	001PD 005PD	•
	±160 mbar		±10 kPa		±15 psi
	±250 mbar		±25 kPa		±30 psi
400MD	±400 mbar		±40 kPa		±60 psi
600MD	±600 mbar	060KD	±60 kPa	100PD	±100 psi
001BD	±1 bar		±100 kPa	150PD	±150 psi
1.6BD	±1.6 bar		±160 kPa		
2.5BD 004BD	±2.5 bar		±250 kPa ±400 kPa		
006BD			±600 kPa		
	±10 bar		±1 MPa		
	Gage		Gage		Gage
2.5MG	0 mbar to 2.5 mbar	250LG	0 Pa to 250 Pa	001NG	0 inH <sub>2</sub> O to 1 inH <sub>2</sub> O
	0 mbar to 4 mbar		0 Pa to 400 Pa		0 inH <sub>2</sub> O to 2 inH <sub>2</sub> O
06MG	0 mbar to 6 mbar	600LG	0 Pa to 600 Pa	004NG	0 inH <sub>2</sub> O to 4 inH <sub>2</sub> O
010MG	0 mbar to 10 mbar	001KG	0 kPa to 1 kPa	005NG	$0 \text{ inH}_2 O \text{ to } 5 \text{ inH}_2 O$
	0 mbar to 16 mbar	1.6KG	0 kPa to 1.6 kPa		0 inH <sub>2</sub> O to 10 inH <sub>2</sub> O
	0 mbar to 25 mbar	2.5KG			0 inH <sub>2</sub> O to 20 inH <sub>2</sub> O
	0 mbar to 40 mbar 0 mbar to 60 mbar		0 kPa to 4 kPa 0 kPa to 6 kPa		0 inH <sub>2</sub> O to 30 inH <sub>2</sub> O 0 psi to 1 psi
	0 mbar to 100 mbar				0 psi to 5 psi
	0 mbar to 160 mbar		0 kPa to 16 kPa		0 psi to 15 psi
	0 mbar to 250 mbar		0 kPa to 25 kPa		0 psi to 30 psi
	0 bar to 400 mbar	040KG	0 kPa to 40 kPa	060PG	0 psi to 60 psi
	0 bar to 600 mbar		0 kPa to 60 kPa		0 psi to 100 psi
	0 bar to 1 bar		0 kPa to 100 kPa	150PG	0 psi to 150 psi
001BG		160KG	0 kPa to 160 kPa		
1.6BG	0 bar to 1.6 bar		0 kPa to 250 kPa		
1.6BG 2.5BG	0 bar to 2.5 bar	250KG	0 kPa to 250 kPa 0 kPa to 400 kPa		
1.6BG		250KG 400KG	0 kPa to 250 kPa 0 kPa to 400 kPa 0 kPa to 600 kPa		

# **TruStability™ Board Mount Pressure Sensors**

**RSC** Series

#### Table 6. Pressure Range Specifications for ±1.6 mbar to ±10 bar

Pressure Range	Pres Rar	nge	Unit	Working	Over	Burst	Common Mode	Total Error Band⁵	Total Error Band after	Long-term Stability	Effective Number of
(see Figure 3)	Pmin.	Pmax.		Pressure <sup>1</sup>	Pressure <sup>2</sup>	Pressure <sup>3</sup>	Pressure <sup>4</sup>	(%FSS)	Auto-Zero <sup>6</sup> (%FSS)	1000 hr, 25°C (%FSS)	at 20 SPS <sup>7</sup>
						Absol	ute				
001BA	0	1	bar	_	2	4	_	±0.75	±0.25	±0.25	16
1.6BA	0	1.6	bar	—	4	8	_	±0.75	±0.25	±0.25	16
2.5BA	0	2.5	bar	_	6	8	_	±0.75	±0.25	±0.25	16
004BA	0	4	bar	_	8	16	_	±0.75	±0.25	±0.25	16
006BA	0	6	bar	_	17	17	_	±0.75	±0.25	±0.25	15
010BA	0	10	bar	—	17	17	—	±0.75	±0.25	±0.25	16
						Differe	ntial				
1.6MD	-1.6	1.6	mbar	335	675	1000	3450	±3	±0.5	±0.5	16
2.5MD	-2.5	2.5	mbar	335	675	1000	3450	±2	±0.5	±0.35	14
004MD	-4	4	mbar	335	675	1000	3450	±2	±0.5	±0.35	15
006MD	-6	6	mbar	335	675	1000	3450	±2	±0.5	±0.35	16
010MD	-10	10	mbar	375	750	1250	5450	±0.75	±0.25	±0.25	16
016MD	-16	16	mbar	375	750	1250	5450	±1	±0.25	±0.25	17
025MD	-25	25	mbar	435	850	1350	10450	±1	±0.25	±0.25	18
040MD	-40	40	mbar	435	850	1350	10450	±0.75	±0.25	±0.25	15
060MD	-60	60	mbar	_	850	1000	10000	±0.75	±0.25	±0.25	15
100MD	-100	100	mbar	_	1400	2500	10000	±0.75	±0.25	±0.25	15
160MD	-160	160	mbar		1400	2500	10000	±0.75	±0.25	±0.25	16
250MD	-250	250	mbar		1400	2500	10000	±0.75	±0.25	±0.25	16
400MD	-400	400	mbar	—	2000	4000	10000	±0.75	±0.25	±0.25	15
600MD	-600	600	mbar	—	2000	4000	10000	±0.75	±0.25	±0.25	16
001BD	-1	1	bar	—	4	8	10	±0.75	±0.25	±0.25	16
1.6BD	-1.6	1.6	bar	—	8	16	10	±0.75	±0.25	±0.25	16
2.5BD	-2.5	2.5	bar		8	16	10	±0.75	±0.25	±0.25	16
004BD	-4.0	4.0	bar		16	17	10	±0.75	±0.25	±0.25	16
006BD	-6	6	bar		17	17	17	±0.75	±0.25	±0.25	16
010BD	-10	10	bar	—	17	17	17	±0.75	±0.25	±0.25	17
						Gag	e				
2.5MG	0	2.5	mbar	335	675	1000	3450	±3	±0.5	±0.5	15
004MG	0	4	mbar	335	675	1000	3450	±3	±0.5	±0.5	16
006MG	0	6	mbar	335	675	1000	3450	±2	±0.5	±0.35	15
010MG	0	10	mbar	335	675	1000	3450	±0.75	±0.25	±0.35	15
016MG	0	16	mbar	335	675	1000	3450	±0.75	±0.25	±0.25	16
025MG	0	25	mbar	375	750	1250	5450	±1	±0.25	±0.25	17
040MG	0	40	mbar	375	750	1250	5450	±0.75	±0.25	±0.25	15
060MG	0	60	mbar	_	850	1000	5450	±0.75	±0.25	±0.25	14
100MG	0	100	mbar	_	850	1000	10000	±0.75	±0.25	±0.25	15
160MG	0	160	mbar	_	850	1000	10000	±0.75	±0.25	±0.25	16
250MG	0	250	mbar		1400	2500	10000	±0.75	±0.25	±0.25	15
400MG	0	400	mbar	—	2000	4000	10000	±0.75	±0.25	±0.25	14
600MG	0	600	mbar	_	2000	4000	10000	±0.75	±0.25	±0.25	15
001BG	0	1	bar	_	2	4	10	±0.75	±0.25	±0.25	16
1.6BG	0	1.6	bar		4	8	10	±0.75	±0.25	±0.25	16
2.5BG	0	2.5	bar	_	8	16	10	±0.75	±0.25	±0.25	15
004BG	0	4	bar		8	16	16	±0.75	±0.25	±0.25	16
006BG	0	6	bar		17	17	17	±0.75	±0.25	±0.25	15
	0	10	bar		17	17	17	±0.75	±0.25	±0.25	16

<sup>2</sup>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.

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. <sup>4</sup>Common Mode Pressure: The maximum pressure that can be applied simultaneously to both ports of a differential pressure sensor without causing changes in specified performance.

<sup>5</sup>Total Error Band: The maximum deviation from the ideal transfer function over the entire compensated temperature and pressure range. Includes all errors due to offset, full scale span, pressure non-linearity, pressure hysteresis, repeatability, thermal effect on offset, thermal effect on span, and thermal hysteresis (see Figure 1). <sup>6</sup>Total Error Band after 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. <sup>7</sup>Effective Number of Bits (ENOB): A measure of the dynamic performance of an analog-to-digital converter (ADC) and its related circuitry. ENOB is defined for the RSC Series per the following equation: ENOB = log<sub>2</sub> (Full Scale Span/Noise).

#### Table 7 Pressure Range Specifications for +160 Pa to +1 MPa

Pressure Range	Pres Rai	sure nge		Working	Over	Burst	Common	Total Error	Total Error Band after	Long-term Stability	Effective Number of
(see Figure 3)	Pmin.	Pmax.	Unit	Pressure <sup>1</sup>	Pressure <sup>2</sup>	Pressure <sup>3</sup>	Mode Pressure⁴	Band⁵ (%FSS)	Auto-Zero <sup>6</sup> (%FSS)	1000 hr, 25°C (%FSS)	
					1	Absol	ute				
100KA	0	100	kPa	_	200	400	_	±0.75	±0.25	±0.25	16
160KA	0	160	kPa	_	400	800	_	±0.75	±0.25	±0.25	16
250KA	0	250	kPa	_	600	800	_	±0.75	±0.25	±0.25	16
400KA	0	400	kPa	_	800	1600	_	±0.75	±0.25	±0.25	16
600KA	0	600	kPa	_	1700	1700	_	±0.75	±0.25	±0.25	15
001GA	0	1	MPa	_	1700	1700	_	±0.75	±0.25	±0.25	16
OUIUA	0	1	IVII G		1100	Differe		1 10.15	±0.25	1 ±0.23	10
160LD	-160	160	Pa	33500	67500	100000	345000	±3	±0.5	±0.5	16
250LD	-250		Pa	33500	67500	100000	345000	±2	±0.5	±0.35	14
400LD	-400		Pa	33500	67500	100000	345000	±2	±0.5	±0.35	15
600LD	-600		Pa	33500	67500	100000	345000	±2	±0.5	±0.35	16
001KD	-1	1	kPa	37.5	75	125	545	±0.75	±0.25	±0.25	16
1.6KD	-1.6	1.6	kPa	37.5	75	125	545	±1	±0.25	±0.25	17
2.5KD	-2.5	2.5	kPa	43.5	85	135	1045	±1 ±1	±0.25	±0.25	18
004KD	-4	4	kPa	43.5	85	135	1045	±0.75	±0.25	±0.25	15
004KD	-6	6	kPa	-	85	100	1000	±0.75	±0.25	±0.25	15
010KD	-10	10	kPa		140	250	1000	±0.75	±0.25	±0.25	16
016KD	-16	16	kPa	_	140	250	1000	±0.75	±0.25	±0.25	17
025KD	-25	25	kPa	_	140	250	1000	±0.75	±0.25	±0.25	16
040KD	-40	40	kPa	_	200	400	1000	±0.75	±0.25	±0.25	17
040KD	-60	60	kPa		200	400	1000	±0.75	±0.25	±0.25	16
100KD	-100		kPa		400	800	1000	±0.75	±0.25	±0.25	16
160KD	-160		kPa		800	1600	1000	±0.75	±0.25	±0.25	16
250KD	-250		kPa		800	1600	1000	±0.75	±0.25	±0.25	16
400KD	-400		kPa		1600	1700	1000	±0.75	±0.25	±0.25	16
600KD	-600		kPa	_	1700	1700	1700	±0.75	±0.25	±0.25	16
001GD	-1	1	MPa		1.7	1.7	1.7	±0.75	±0.25	±0.25	17
OOTOD	_ <u>+</u>	-	IVII G		1.1	Gag	1	10.15	10.20	10.20	1
250LG	0	250	Pa	33500	67500	100000	345000	±3	±0.5	±0.5	15
400LG	0	400	Pa	33500	67500	100000	345000	±3	±0.5	±0.5	16
400LG	0	600	Pa	33500	67500	100000	345000	±2	±0.5	±0.35	15
000LG 001KG	0	1	kPa	33.5	67.5	100000	345	±0.75	±0.25	±0.35	15
1.6KG	0	1.6	kPa	33.5	67.5	100	345	±0.75	±0.25	±0.25	16
2.5KG	0	2.5	kPa	37.5	75	125	545	±0.75	±0.25	±0.25	17
2.5KG	0	4	kPa	37.5	75	125	545	±0.75	±0.25	±0.25	15
004kg 006Kg	0	6	kPa kPa	37.5	85	125	545	±0.75 ±0.75	±0.25 ±0.25	±0.25 ±0.25	15
010KG	0	10	kPa kPa	_	85	100	1000	±0.75 ±0.75	±0.25 ±0.25	±0.25	14
	1			_							
016KG	0	16	kPa kDa		85 140	100 250	1000	±0.75	±0.25	±0.25	16
025KG 040KG	0	25 40	kPa kPa	_	200	400	1000 1000	±0.75 ±0.75	±0.25 ±0.25	±0.25 ±0.25	15 14
040KG 060KG	0	60	kPa kPa		200	400	1000	±0.75 ±0.75	±0.25 ±0.25	±0.25	14
100KG		100	kPa kPa		200	400	1000	±0.75 ±0.75	±0.25 ±0.25	±0.25 ±0.25	15
	0			_							
160KG 250KG	0	160	kPa kDa		400	800	1000 1000	±0.75	±0.25 ±0.25	±0.25	16
	0	250	kPa kDa	_	800	1600 1600	1600	±0.75		±0.25	15
400KG	0	400	kPa kDa	_	800			±0.75 ±0.75	±0.25 ±0.25	±0.25	16
600KG	0	600	kPa MDa		1700	1700	1700	1		±0.25	15
001GG	0	1	MPa	-	1.7	1.7	1.7	±0.75	±0.25	±0.25	16

<sup>1</sup>Working Pressure: The maximum pressure that may be applied to any port of the sensor in continuous use. This pressure may be outside the operating pressure range limits (Pmin. to Pmax.) in which case the sensor may not provide a valid output until pressure is returned to within the operating pressure range. Tested to 1 million cycles, minimum.

<sup>2</sup>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.

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.

<sup>4</sup>Common Mode Pressure: The maximum pressure that can be applied simultaneously to both ports of a differential pressure sensor without causing changes in specified performance.

<sup>5</sup>Total Error Band: The maximum deviation from the ideal transfer function over the entire compensated temperature and pressure range. Includes all errors due to offset, full scale span, pressure non-linearity, pressure hysteresis, repeatability, thermal effect on offset, thermal effect on span, and thermal hysteresis (see Figure 1). <sup>6</sup>Total Error Band after 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. <sup>7</sup>Effective Number of Bits (ENOB): A measure of the dynamic performance of an analog-to-digital converter (ADC) and its related circuitry. ENOB is defined for the RSC Series per the following equation: ENOB = log<sub>2</sub> (Full Scale Span/Noise).

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# **TruStability™ Board Mount Pressure Sensors**

**RSC** Series

Table	8. Pressure	Range	Specifications	for ±0.5 i	nH.O to ±
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Pressure Range	Rar	Pressure Range		Working	Over	Burst	Common	Total Error	Total Error Band after	Long-term Stability	Effective Number of
(see <u>ii</u> xe Figure 3) E E	Pmax.	Unit	Pressure <sup>1</sup>	Pressure <sup>2</sup>	Pressure <sup>3</sup>	Mode Pressure⁴	Band⁵ (%FSS)		1000 hr, 25°C (%FSS)		
						Absolu	te				
015PA	0	15	psi	_	30	60	_	±0.75	±0.25	±0.25	16
030PA	0	30	psi	_	60	120	_	±0.75	±0.25	±0.25	16
060PA	0	60	psi	_	120	240	_	±0.75	±0.25	±0.25	16
100PA	0	100	psi	_	250	250	_	±0.75	±0.25	±0.25	16
150PA	0	150	psi	_	250	250	_	±0.75	±0.25	±0.25	16
						Differer	ntial				
0.5ND	-0.5	0.5	inH <sub>2</sub> O	135	270	415	1400	±3	±0.5	±0.5	16
001ND	-1	1	inH <sub>2</sub> O	135	270	415	1400	±2	±0.5	±0.35	15
002ND	-2	2	inH <sub>2</sub> O	135	270	415	1400	±2	±0.5	±0.35	16
004ND	-4	4	inH <sub>2</sub> O	150	300	500	2200	±0.75	±0.25	±0.25	17
005ND	-5	5	inH <sub>2</sub> O	150	300	500	2200	±1	±0.5	±0.25	19
010ND	-10	10	inH <sub>2</sub> O	175	350	550	4200	±1	±0.25	±0.25	19
020ND	-20	20	inH <sub>2</sub> O	175	350	550	4200	±0.75	±0.25	±0.25	16
030ND	-30	30	inH <sub>2</sub> O	175	350	550	4200	±0.75	±0.25	±0.25	16
001PD	-1	1	psi	_	10	15	150	±0.75	±0.25	±0.25	15
005PD	-5	5	psi	_	30	40	150	±0.75	±0.25	±0.25	17
015PD	-15	15	psi	_	60	120	150	±0.75	±0.25	±0.25	17
030PD	-30	30	psi	_	120	240	150	±0.75	±0.25	±0.25	17
060PD	-60	60	psi	_	250	250	250	±0.75	±0.25	±0.25	17
100PD	-100	100	psi	_	250	250	250	±0.75	±0.25	±0.25	17
150PD	-150	150	psi	_	250	250	250	±0.75	±0.25	±0.25	17
					,	Gage					
001NG	0	1	inH <sub>2</sub> 0	135	270	415	1400	±3	±0.5	±0.5	16
002NG	0	2	inH <sub>2</sub> O	135	270	415	1400	±2	±0.5	±0.35	15
004NG	0	4	inH <sub>2</sub> O	135	270	415	1400	±0.75	±0.25	±0.35	16
005NG	0	5	inH <sub>2</sub> O	135	270	415	1400	±0.75	±0.25	±0.25	16
010NG	0	10	inH <sub>2</sub> O	150	300	500	2200	±1	±0.25	±0.25	18
020NG	0	20	inH <sub>2</sub> O	175	350	550	4200	±0.75	±0.25	±0.25	15
030NG	0	30	inH <sub>2</sub> O	175	350	550	4200	±0.75	±0.25	±0.25	15
001PG	0	1	psi	_	10	15	150	±0.75	±0.25	±0.25	14
005PG	0	5	psi	_	30	40	150	±0.75	±0.25	±0.25	16
015PG	0	15	psi	_	30	60	150	±0.75	±0.25	±0.25	16
030PG	0	30	psi	_	60	120	150	±0.75	±0.25	±0.25	16
060PG	0	60	psi	_	120	240	250	±0.75	±0.25	±0.25	16
100PG	0	100	psi	_	250	250	250	±0.75	±0.25	±0.25	16
150PG	0	150	psi	_	250	250	250	±0.75	±0.25	±0.25	16

Working Pressure: The maximum pressure that may be applied to any port of the sensor in continuous use. This pressure may be outside the operating pressure range limits (Pmin. to Pmax.) in which case the sensor may not provide a valid output until pressure is returned to within the operating pressure range. Tested to 1 million cycles, minimum.

<sup>2</sup>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.

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. <sup>4</sup>Common Mode Pressure: The maximum pressure that can be applied simultaneously to both ports of a differential pressure sensor without causing changes in

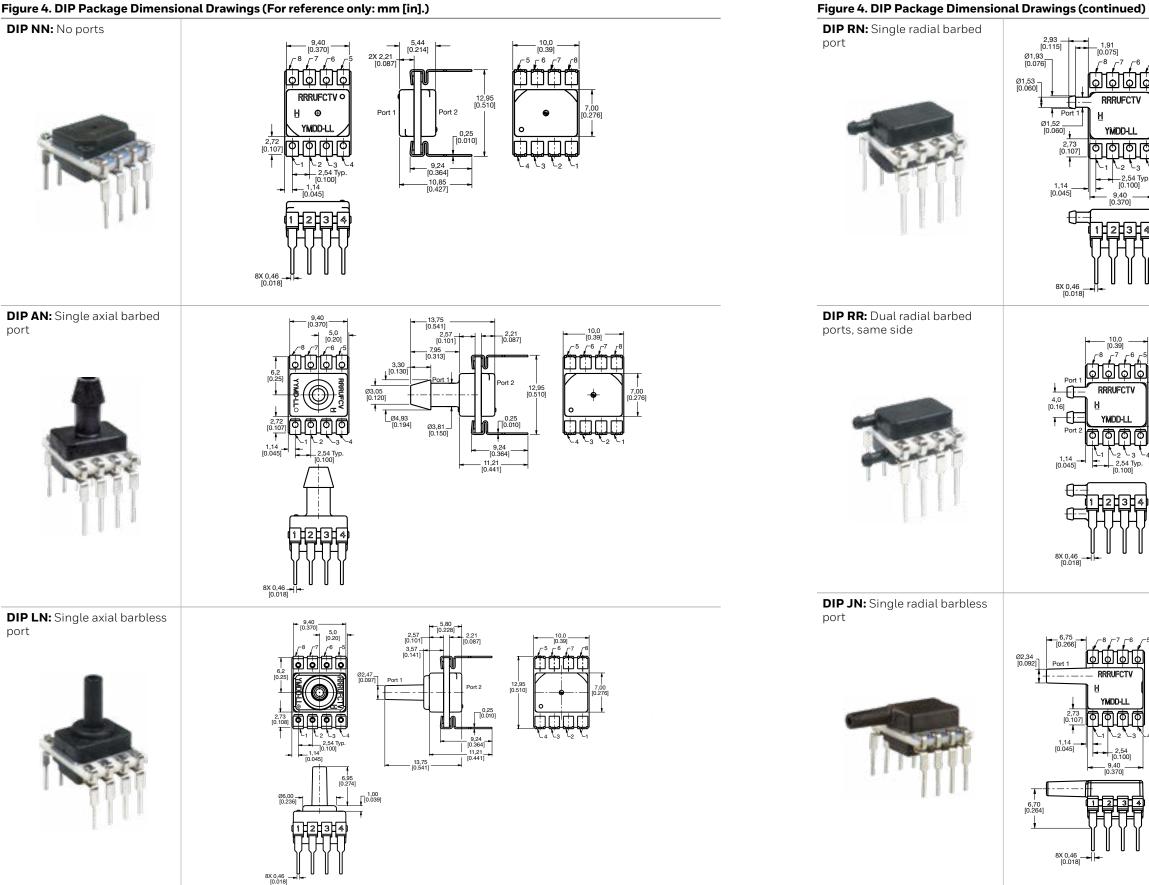
specified performance.

<sup>5</sup>Total Error Band: The maximum deviation from the ideal transfer function over the entire compensated temperature and pressure range. Includes all errors due to offset, full scale span, pressure non-linearity, pressure hysteresis, repeatability, thermal effect on offset, thermal effect on span, and thermal hysteresis (see Figure 1). <sup>6</sup>Total Error Band after 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.
 <sup>7</sup>Effective Number of Bits (ENOB): A measure of the dynamic performance of an analog-to-digital converter (ADC) and its related circuitry. ENOB is defined for the RSC Series per the following equation: ENOB = log<sub>2</sub> (Full Scale Span/Noise).

#### ±150 psi

# TruStability<sup>™</sup> Board Mount Pressure Sensors RSC Series

## Figure 4. DIP Package Dimensional Drawings (For reference only: mm [in].)





# TruStability<sup>™</sup> Board Mount Pressure Sensors RSC Series

Ø1,93

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8X 0,46 [0.018]

8X 0,46

8X 0,46

Ø2,34

RRRUFCTV

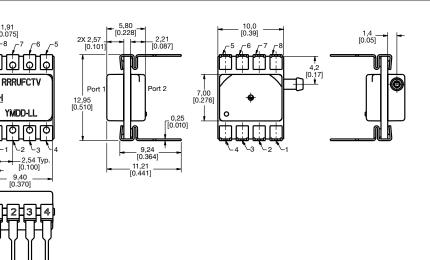
YMDD-LL

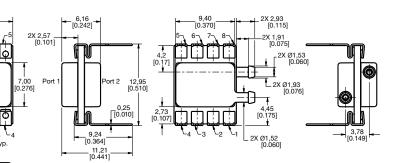
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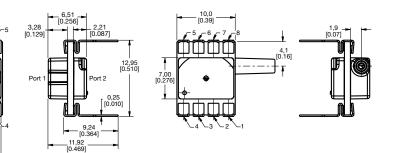
YMDD-LL

- \_\_\_\_ RRRUFCTV

Ø1,53

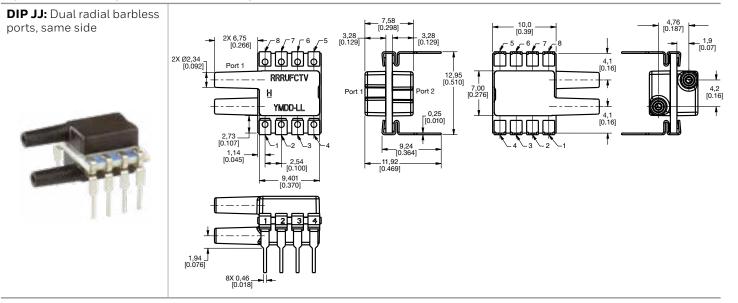






# **TruStability™ Board Mount Pressure Sensors RSC** Series

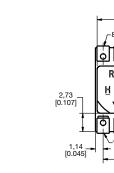
## Figure 4. DIP Package Dimensional Drawings (continued)

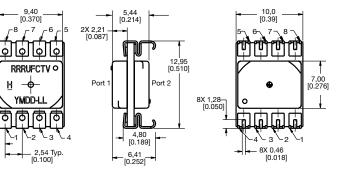


## Figure 5. SMT Package Dimensional Drawings (For reference only: mm [in].)

SMT NN: No ports

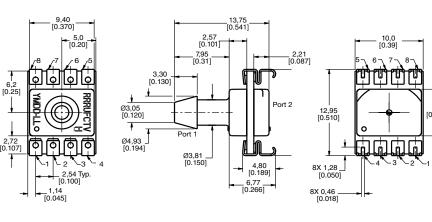










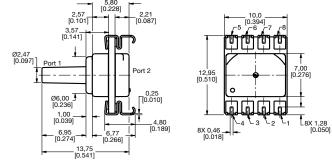


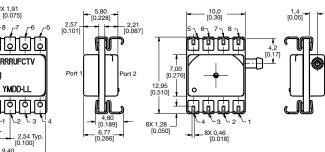
## **12** sps.honeywell.com/ast

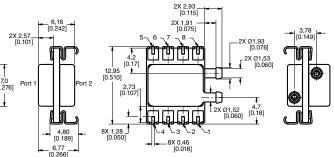


# TruStability<sup>™</sup> Board Mount Pressure Sensors RSC Series

# Figure 5. SMT Package Dimensional Drawings (continued) SMT LN: Single axial barbless port SMT RN: Single radial barbed port Ø1,53 RRRUFCT Port 1 Ø1,52 YMDD-LL SMT RR: Dual radial barbed ports, same side QQ RRUFCT





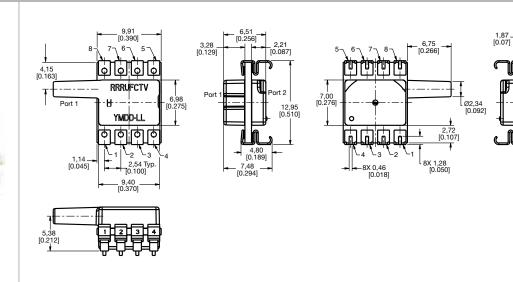


# **TruStability™ Board Mount Pressure Sensors RSC** Series

#### Figure 5. SMT Package Dimensional Drawings (continued)

SMT JN: Single radial barbless port





### SMT JJ: Dual radial barbless ports, same side 2X 6,75 [0.187 فالفالفالف וןטוורי . RRRUFCTV 4,162 4,162 0.1639] Port 2 Н 6,981 0.275] ---YMDD-LL ڡؙڵڡٛڵڡ 1,85 8X 1 28 1,14 1,50

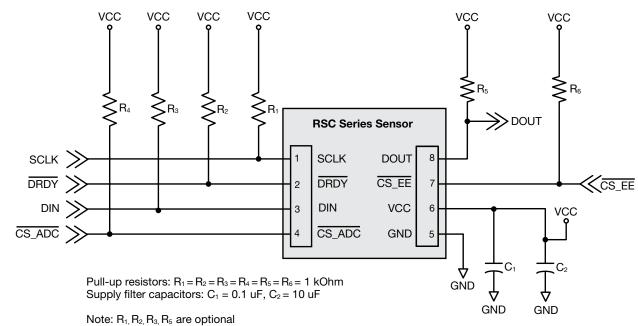
## Figure 6. Recommended PCB Pad Layouts



# TruStability<sup>™</sup> Board Mount Pressure Sensors RSC Series

le 9. Pinout		
Pin	Name	Description
1	SCLK	external clock source
2	DRDY	data ready: active low
3	DIN	serial data input
4	CS_ADC	ADC chip select: active low
5	GND	ground
6	V <sub>CC</sub>	positive supply voltage
7	CS_EE	EEPROM chip select: active low
8	DOUT	serial data output

#### Figure 7. Recommended Circuit



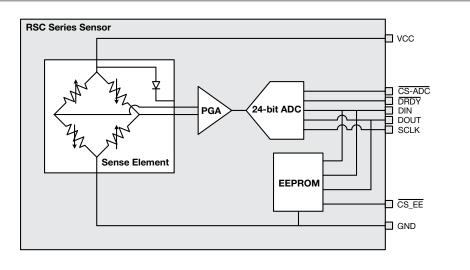


## 1.0 SYSTEM OVERVIEW

### 1.1 Major System Blocks (see Figure 1-1)

- A piezoresistive Sense Element that provides a signal that changes when pressure is applied to the device.
- An Analog to Digital Converter (ADC) with an integrated amplifier that measures this signal. (Unlike many conventional sensors, this digital signal is neither compensated nor calibrated.)
- An onboard EEPROM Memory that contains the coefficients for compensating equations that can be used to correct the raw signal and provide a fully temperature-compensated, pressure-calibrated value.

#### Figure 1-1. Block Diagram



#### 1.2 High-level Operating Sequence

The following operating sequence is required to make the device function. Each step is discussed in detail in the following sections.

- 1. Read the ADC settings and the compensation values from EEPROM.
- 2. Initialize the ADC converter using the settings provided in EEPROM.
- 3. Adjust the ADC sample rate if desired.
- 4. Command the ADC to take a temperature reading, and store this reading.
- 5. Give Delay (Example: if sample rate is 330SPS delay for 3.03 ms [1/330 s]).
- 6. Command the ADC to take a pressure reading, and store this reading.
- 7. Apply the compensation formulae to the temperature and pressure readings in order to calculate a pressure value.
- 8. Repeat steps 4, 5 and 6 in a loop to take additional readings.

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It is not necessary to take a new temperature reading in conjunction with every pressure reading. If a fast response to pressure is required, it is possible to take several pressure readings in a row and use an earlier temperature reading to compensate. The exact timing of this will be application specific and depend on the rapidity of possible temperature changes. A temperature reading approximately every 100 ms should be adequate for most applications except those with rapid temperature transients. Longer times between temperature readings may be possible for applications where rapid temperature changes are not possible. If multiple pressure readings for a single temperature reading are desired, the sequence of steps above becomes:

- 4. Command the ADC to take a temperature reading, and store this reading.
- 5. Command the ADC to take a pressure reading, and store this reading.
- 6. Apply the compensation formulae to the temperature and pressure readings in order to calculate a pressure value.
- 7. Repeat steps 5 and 6 in a loop to take additional pressure readings and compensate them.
- 8. After a pre-determined number of loops, repeat step 4.

#### **1.3** Compensation Mathematics (see Table 1-1)

This section gives a high-level overview of the compensation mathematics. Please refer to Section 2.0 for details on exact numeric formats and EEPROM addresses. It is assumed that all values have been correctly converted to a floating-point decimal format.

#### Table 1-1. Coefficients Read from EEPROM

Coefficient	Description
P <sub>Range</sub>	pressure range read from EEPROM
P <sub>min</sub>	pressure offset read from EEPROM
Eng Units	engineering units read from EEPROM
P <sub>raw</sub>	uncompensated pressure reading from ADC
T <sub>raw</sub>	uncompensated temperature reading from ADC
P <sub>int1</sub>	intermediate value in calculations
P <sub>int2</sub>	intermediate value in calculations
P <sub>Comp_FS</sub>	compensated output pressure
P <sub>Comp</sub>	compensated output pressure, in engineering units

 $OffsetCoefficient_3...OffsetCoefficient_0 = Correction values from EEPROM$ SpanCoefficient\_3...SpanCoefficient\_0 = Correction values from EEPROM ShapeCoefficient\_3...ShapeCoefficient\_0 = Correction values from EEPROM

P<sub>int1</sub> = P<sub>raw</sub> - (OffsetCoefficient<sub>3</sub> \* T<sub>raw</sub><sup>3</sup> + OffsetCoefficient<sub>2</sub> \* T<sub>raw</sub><sup>2</sup> + OffsetCoefficient<sub>1</sub> \* T<sub>raw</sub> + OffsetCoefficient<sub>0</sub>) P<sub>int2</sub> = P<sub>int1</sub> / (SpanCoefficient<sub>3</sub> \* T<sub>raw</sub><sup>3</sup> + SpanCoefficient<sub>2</sub> \* T<sub>raw</sub><sup>2</sup> + SpanCoefficient<sub>1</sub> \* T<sub>raw</sub> + SpanCoefficient<sub>0</sub>) P<sub>Comp\_FS</sub> = ShapeCoefficient<sub>3</sub> \* P<sub>int2</sub><sup>3</sup> + ShapeCoefficient<sub>2</sub> \* P<sub>int2</sub><sup>2</sup> + ShapeCoefficient<sub>1</sub> \* P<sub>int2</sub> + ShapeCoefficient<sub>0</sub> P<sub>Comp\_FS</sub> = (P<sub>Comp\_FS</sub> \* P<sub>Range</sub>) + P<sub>min</sub> [Engineering Units]

#### SYSTEM INITIALIZATION – EEPROM 2.0

The device on-board memory contains serialization, pressure range, ADC configuration and compensation information.

#### **EEPROM Contents** 2.1

#### 2.11 Serialization and pressure range information: Stored in bytes 0 to 40 (see Table 2-1).

## Table 2-1. Serialization and Pressure Range Information

Relative Address	ltem	Detail	Data Type	Byte Order
0			ASCII Char	MSB
1	sensor catalog listing		ASCII Char	
2			ASCII Char	
3			ASCII Char	
4			ASCII Char	
5			ASCII Char	
6			ASCII Char	
7			ASCII Char	
8	sensor catalog listing		ASCII Char	
9			ASCII Char	
10			ASCII Char	
11			ASCII Char	
12			ASCII Char	
13			ASCII Char	
14			ASCII Char	
15			ASCII Char	LSB
16			ASCII Char	MSB
17		YYYY	ASCII Char	
18		YYYY	ASCII Char	
19			ASCII Char	LSB
20			ASCII Char	MSB
21	serial number	DDD	ASCII Char	
22	(YYYYDDDXXXX)		ASCII Char	LSB
23			ASCII Char	MSB
24		XXXX	ASCII Char	
25			ASCII Char	
26			ASCII Char	LSB
27				LSB
28			Floot	
29	pressure range		Float	
30				MSB
31				LSB
32				
33	pressure minimum		Float	
34				MSB
35			ASCII Char	MSB
36			ASCII Char	
37	pressure unit		ASCII Char	
38			ASCII Char	
39			ASCII Char	LSB
40	pressure reference		ASCII Char	

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## 2.12 ADC Configuration Settings: Stored in bytes 61, 63, 65 and 67 (See Table 2-2).

#### Table 2-2. ADC Configuration Setttings

<b>Relative Address</b>	ltem	Detail	Data Type	Byte Order
60				
61		ADC CONFIG_00	unsigned character	-
62				
63	ADC configuration	ADC CONFIG_01	unsigned character	-
64	math			
65		ADC CONFIG_02	unsigned character	-
66				
67		ADC CONFIG_03	unsigned character	-

## 2.13 Polynomial coefficients: Stored in bytes 130 to 145 (see Table 2-3).

Table 2-3. Polynomial Coefficients

<b>Relative Address</b>	ltem	Detail	Data Type	Byte Order
130				LSB
131		OffeetCeefficient	floot	
132		OffsetCoefficient <sub>0</sub>	float	
133				MSB
134				LSB
135		OffsetCoefficient <sub>1</sub>	float	
136		OnsetCoentcient <sub>1</sub>	ntoat	
137				MSB
138	offset matrix			LSB
139		OffsetCoefficient <sub>2</sub>	float	
140		OffsetCoefficient <sub>2</sub>	noat	
141				MSB
142				LSB
143		OffsetCoefficient <sub>3</sub>	float	
144		Onseccoentcient <sub>3</sub>	nudt	
145				MSB

## 2.14 Span coefficients: Stored in bytes 210 to 225 (see Table 2-4).

Table 2-4. Span Coefficients

<b>Relative Address</b>	ltem	Detail	Data Type	Byte Order
210				LSB
211		Concer Constitutions	£1 +	
212		SpanCoefficient <sub>0</sub>	float	
213				MSB
214				LSB
215		SpanCoefficient₁	float	
216		Spancoencient	nual	
217				MSB
218	span matrix			LSB
219		SpanCoefficient <sub>2</sub>	float	
220		Spancoencient <sub>2</sub>	noat	
221				MSB
222				LSB
223		SpanCoefficient₃	float	
224		Spancoerficient <sub>3</sub>	nudl	
225				MSB



#### 2.15 Shape Coefficients: Stored in bytes 290 to 305 (see Table 2-5).

#### Table 2-5. Shape Coefficients

<b>Relative Address</b>	Item	Detail	Data Type	Byte Order
290				LSB
291		ShanaCoofficient	float	
292		$ShapeCoefficient_{0}$	nuar	
293				MSB
294				LSB
295		ShapeCoefficient	float	
296		Shapecberncient		
297				MSB
298	shape matrix			LSB
299		ShapeCoefficient <sub>2</sub>	float	
300		Shapecberncient <sub>2</sub>	nuar	
301				MSB
302				LSB
303		ShanaCoofficient	floot	
304		ShapeCoefficient <sub>3</sub>	float	
305				MSB

#### Checksum address: Stored in byte 450 (see Table 2-6). 2.16

#### Table 2-6. Checksum Address

<b>Relative Address</b>	ltem	Detail	Data Type	Byte Order
450	Chaolyour		uncire and all art int	LSB
451	Checksum		unsigned short int	MSB

Any unspecified EEPROM addresses below address 451 are reserved for future enhancements.

#### 2.2 **EEPROM Communications**

The  $\overline{\text{CS}_{\text{EE}}}$  pin of the sensor selects the EEPROM for SPI communication. When  $\overline{\text{CS}_{\text{EE}}}$  is high, the EEPROM is in stand-by mode, and communications with the ADC are possible. When  $\overline{CS\_EE}$  is low, the EEPROM is enabled.  $\overline{CS\_EE}$  and  $\overline{CS\_ADC}$  must never be simultaneously low. EEPROM operates in SPI mode 0 where CPOL = 0 and CPHA = 0 (0,0) and mode 3 where CPOL = 1 and CPHA = 1 (1,1).

Each memory of EEPROM contains 8-bit data or one byte. To read from memory, the host sends an EAD\_EEPROM instruction [0000 X011] followed by an 8-bit address. The 'X' bit in the read instruction is the ninth (MSB) address bit.

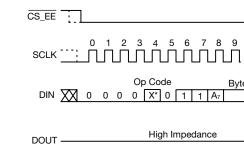
#### Example:

- 1. To read data at address 1, the command sequence is [0000 0011] [0000 0001].
- 2. To read data at address 290, the command sequence is [0000 1011] [0010 0010].

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After receiving the last address bit, the EEPROM responds by shifting out data on the DOUT pin, as shown in Figure 2-1. Sequentially stored data can be read out by simply continuing to run the clock. The internal address pointer is automatically incremented to the next higher address as data is shifted out. After reaching the highest memory address, the address counter "rolls over" to the lowest memory address, and the read cycle can be continued indefinitely. The read operation is terminated by taking CS\_EE high.

## Figure 2-1. EEPROM Communications



#### SYSTEM OPERATION - ADC 3.0

#### **ADC Communications and Initialization** 3.1

The  $\overline{\text{CS}}$  ADC pin of the sensor selects the ADC for SPI communication. When  $\overline{\text{CS}}$  ADC is high, the ADC is in stand-by mode, and communications with the EEPROM are possible. When  $\overline{CS}ADC$  is low, the ADC is enabled.  $\overline{CS}EE$  and  $\overline{CS}ADC$  must never be simultaneously low. The ADC interface operates in SPI mode 1 where CPOL = 0 and CPHA = 1.

The ADC has four configuration registers. Three registers are 'reserved' and must be set to the default values contained in EEPROM. These registers contain setup values that are specific to the pressure sense element, and should not be changed. Configuration register 1 toggles the ADC between pressure and temperature readings and controls the data rate of the ADC.

To program a configuration register, the host sends a WREG command [0100 RRNN], where 'RR' is the register number and 'NN is the number of bytes to be written -1.

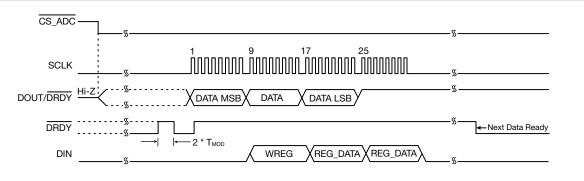
Example: To write the single byte default configuration to register 3, the command is [0100 1100]. It is possible to write the default values to all configuration registers with a single command by setting the address to 0 and the number of bytes to (4-1) = 3, followed by all four configuration bytes in sequence. The command for this is [0100 0011].

The ADC is capable of full-duplex operation, which means commands are decoded at the same time that conversion data are read. Commands may be sent on any 8-bit data boundary during a data read operation. This allows for faster toggling between pressure and temperature modes. A WREG command can be sent without corrupting an ongoing read operation. Figure 3-1 shows an example of sending a WREG command while reading conversion data. Note that after the command is clocked in (after the 32nd SCLK falling edge), the sensor changes settings and starts converting using the new register settings. The WREG command can be sent on any of the 8-bit boundaries - the first, ninth, 17th or 25th SCLK rising edges as shown in Figure 3-1.



e Address
D7 D6 D5 D4 D3 D2 D1 D0 MSB

### Figure 3-1. ADC Communciations and Initialization



#### 3.2 **Programming the Data Rate and Pressure/Temperature Modes**

The ADC configuration register 1 contains the settings for the data rate and determines whether the ADCS takes a pressure reading or a temperature reading. This register can be changed as shown in Table 3-1 by using a WREG command. Typical data conversion times are shown in Table 3-2.

#### Table 3-1. ADC Configuration Register

ADC_CONFIG_01 [HEX]	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit O
01h		DR[2:0]		MOD	E[1:0]	1	TS	0
	Data Ra			Operating Mod		set to 1	Temperature Sensor Mode	set to O
	000: 20 001: 45 010: 90 011: 175 100: 33 101: 60 110: 100 111: not	5 0 00 t used 0 (default) 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	)	00: Normal Mo modulator cloc 01: not used 10: Fast Mode modulator cloc	k) (default) (512 kHz		O: Pressure (sense element) reading 1: Temperature reading	

#### Table 3-2. Typical Data Conversion Times

Normal Mode		Fast Mode	
SPS	Time (ms)	SPS	Time (ms)
20	49.99	40	25.00
45	22.25	90	11.12
90	11.26	180	5.63
175	5.78	350	2.89
330	3.04	660	1.52
600	1.68	1200	0.84
1000	1.01	2000	0.51

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#### ADC Reset Command 3.3

The ADC reset command RESET [0000 0110] resets the ADC to the default values.

#### ADC Programming Sequence – Power Up 3.4

At power-up it is necessary to initialize all the ADC registers. The sequence is:

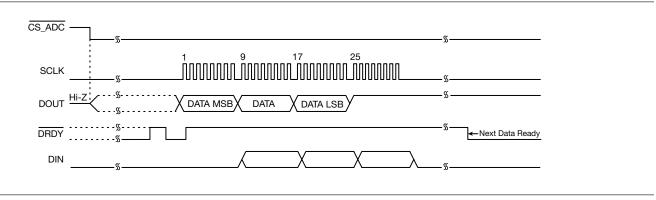
- 1. Set the CS\_EE to high to disable EEPROM communication.
- 2. Set the  $\overline{CS}ADC$  to low to enable ADC communication.
- - Send the the Reset command (06h) to make sure the ADC is properly reset after powerup

Both a temperature and an uncompensated pressure reading are necessary to calculate a compensated value (see Section 3.5).

#### ADC Programming and Read Sequence – Temperature Reading (see Figure 3-2 and Table 3-3) 3.5

- 1. Set the  $\overline{CS}ADC$  low to enable ADC communication.
- be set to 1.
- 3. Send 08h command to start data conversion on ADC.

## Figure 3-2. ADC Programming and Read Sequence – Temperature Reading



is represented in 2's complement format. MSB = 0 indicates positive result, MSB = 1 indicates negative value.

To convert the digital value to a Celsius temperature, first check if the MSB is 0 or 1. If the MSB = 0, simply multiply the decimal code by 0.03125°C to obtain the result. If the MSB = 1, subtract 1 from the result and complement all bits, multiply the result by -0.03125°C.



3. Initialize all four configuration registers to the default values in the EEPROM's Relative addresses 61, 63, 65 and 67 (see the MSB bytes in see Section 3.0) by sending a WREG command to address 0 [0100 0011] followed by the four bytes of data:

• Write the respective register configuration using the WREG command (Example: 43h, 0Ah, 84h, 40h, and 00h)

2. Configure the sensor to temperature mode and the desired data rate by setting configuration register 1 by sending a WREG command to address 1, [0100 0100] followed by the single configuration byte. Bit 1 (TS) of the configuration register should

4. The sensor will start to output the requested data on DOUT at the first SCLK rising edge after the command byte is received.

5. Interpret the data as follows: Temperature data are output starting with MSB. When reading 24 bits, the first 14 bits are used to indicate the temperature measurement result. The last 10 bits are random data and must be ignored. Negative temperature

#### Table 3-3. Data Interpretation Table

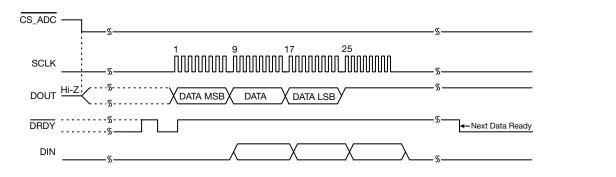
Temperature (°C)	Digital Output (Binary)	Hex
128	01 0000 0000 0000	1000
127.96875	00 1111 1111 1111	OFFF
100	00 1100 1000 0000	0C80
80	00 1010 0000 0000	00A0
75	00 1001 0110 0000	0960
50	00 01 10 01 00 00 00 00 00 00 00 00 00 0	0640
25	00 0011 0010 0000	0320
0.25	00 0000 0000 1000	0008
0	00 0000 0000 0000	0000
-0.25	11 1111 1111 1000	3FF8
-25	11 1100 1110 0000	3CE0
-40	11 1011 0000 0000	3B00

Example 1: The ADC reads back 0960h: 0960h has an MSB = 0. (0960h) × (0.03125°C) = (2400) × (0.03125°C) = 75°C Example 2: The ADC reads back: 3CEOh: 3CEOh has an MSB = 1. Complement the result: 3CEOh = 0320h (0320h) × (-0.03125°C)  $=(800) \times (-0.03125^{\circ}C) = -25^{\circ}C$ 

#### ADC Programming and Read Sequence – Pressure Reading (see Figure 3-3) 3.6

- Set the CS\_ADC low to enable ADC communication. 1.
- 2. Configure the sensor to the pressure mode and the desired data rate by setting configuration register 1 by sending a WREG command to address 1, [0100 0100] followed by the single configuration byte. Bit 1 (TS) of the configuration register should be set to 0.
- Send 08h command to start data conversion on ADC. З.
- 4. The sensor will start to output the requested data on DOUT at the first SCLK rising edge after the command byte is received.

## Figure 3-3. ADC Programming and Read Sequence – Pressure Reading



5. Interpret the data as shown in Table 3-4. Pressure data are output starting with MSB, in 24-bit 2's complement format.

## Table 3-4. CompReturn\_Struct

Input Signal, VIN (AINP-AINN)	DEAL OUTPUTCODE
≥+FS(2 <sup>23</sup> -1)/2 <sup>23</sup>	7FFFFh
+FS/2 <sup>23</sup>	000001h
0	0
-FS / 2 <sup>23</sup>	FFFFh
≤-FS	800000h

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#### **EXAMPLE SOFTWARE** 4.0

#### 4.1 Data Types

Specific data types defined by the Pressure\_Comp module defined in "Pressure\_Comp.h" are needed while interacting with the pressure compensation function (see Table 4-1).

#### Table 4-1. Data Types

Name	Description	
	Provides an enumerated data typ	e t
	compensation states are given be	elo
	COMPINIT_OK	0
	COMPINIT_NOK	C
CompStatus_Enum	CRC_FAILURE	C
	IP_PRESSURE_OUTOFRANGE	h
	IP_TEMP_OUTOFRANGE	h
	PRESSURE_VALID	C
	PRESSURE_INVALID	C
	Provides structured a data type c	on
	CompStatus; details are given be	lov
CompReturn_Struct	f22Durana Outra t	F
	f32PressureOutput	F
	CompStatus	d

#### 4.2 Function Descriptions – Pressure\_Comp.c

"Pressure\_Comp.c" provides the source code that provides functions to initialize the module by extracting all the coefficients from EEPROM after CRC validation and extracting the coefficients from it. This file also provides the function to compensate the pressure by having uncompensated raw pressure and temperature input. The "Pressure\_Comp.h" file provides the interfaces to the functions implemented in the "Pressure\_Comp.c" file that need to be included in the application where the pressure compensation is needed. Dependencies: "float.h", "crc.h" (see Tables 4-2, 4-3 and 4-4 ).

#### Table 4-2. Compensate\_Pressure\_Init()

Entity	Name	Description
Function	Compensate_Pressure_Init	Initializes the pressure compensation module
		Data Type: (unsigned char *)
Parameter	u8EEPROM_ptr	Provides a pointer to the EEPROM image which is read byte-wise in
		a contiguous memory buffer
	CompStatus_Enum	Returns the status of compensation initialization (either of the
		compensation states given below)
Return Type		COMPINIT_OK Compensation init successful
		COMPINIT_NOK Compensation init failure



to hold the status of pressure compensation module; pressure
ow:
Compensation init successful
Compensation init failure
CRC check failure
Input pressure out of range
Input temperature out of range
Output pressure is valid
Output pressure is invalid
ntaining two elements such as f32PressureOutput and
w:
Provides output pressure of "float" data type
Provides status of pressure compensation of "CompStatus_Enum"
data type

### Table 4-3. Compensate\_Pressure()

Entity	Name	Description
Function	Compensate_Pressure	Provides the compensated pressure based on the polynomial correction
Parameter	u32PressureInput	Data Type: (unsigned long int)
		Inputs the uncompensated pressure as read by the sensor
	u32Temperature	Data Type: (unsigned long int)
		Inputs the temperature as read by the sensor
Return type	CompReturn_Struct.	Data Type: (CompStatus_Enum)
	CompStatus	Provides the status of the compensation initialization
	CompReturn_Struct. f32PressureOutput	Data Type: (float)
		Returns the compensated pressure output in engineering units per the
		sensor's specification

## Table 4-4. AutoZero\_Pressure()

Entity	Name	Description
Function		Sets a known, preset pressure to 50% full scale pressure (this function
	Autozoro Drocouro	should only be used at a known preset pressure that has to be output as
	Autozero_Pressure	50% full scale pressure)
		The term "autozero" refers to 50% full scale pressure
Parameter	u32PressureZero	Data Type: (unsigned long int)
		Inputs uncompensated pressure as read by the TSHUR sensor at preset
		50% full scale pressure
	u32TemperatureZero	Data Type: (unsigned long int)
		Inputs temperature as read by the TSHUR sensor at preset 50% full scale
		pressure
Return type	CompReturn_Struct.	Data Type: (CompStatus_Enum)
	CompStatus	Returns the status of AutoZero Correction

#### 4.3 **Checksum Calculation**

"crc.c" provides a source code which, in turn, provides the functions to compute the 16-bit CCITT CRC. "crc.h" is an interface file for "pressure\_Comp.c" to get the interfaces to the functions which are implemented in the "crc.c" file (see Table 4-5).

#### Table 4-5. CrcComputeCrc16()

Entity	Name	Description
Function		Computes the 16-bit CRC-16-CCITT checksum
	CrcComputeCrc16	Uses a lookup table to compute the CRC-16-CCITT checksum with the
		generator polynomial = 0x1021
Parameter	u8Data	Data Type: (unsigned char)
		Provides the current data passed to compute the CRC
	u16CurrCrc	Data Type: (unsigned short int)
		Provides the previously computed CRC Checksum
Return type	unsigned short int	Returns the updated CCITT 16 bit CRC

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#### **Compensation Sequence** 4.4

- 1. Defines section (set only one of the following):
  - If little-endian, set "#define LITTLE\_ENDIAN\_FORMAT"
  - If big-endian, set "#define BIG\_ENDIAN\_FORMAT"
- 3. Include the interface "#include "Pressure\_Comp.h" in the source file where the pressure needs to be compensated.
- 2. Include the four source files "Pressure\_Comp.c", "Pressure\_Comp.h", "crc.c", "crc.h" into the project build directory structure. Read and store the EEPROM contents in the application memory. 4.
- 5. Initialize the "Pressure\_Comp" module by calling the Compensate\_Pressure\_Init() function by passing the buffer pointer to the function. Check for the return status of type "CompStatus\_Enum" ensure the same is "COMPINIT\_OK".
- 6 Set the reference pressure and temperature at which the AutoZero correction should happen. Read the raw pressure and temperature data from the sensor, pass the same as parameters to the AutoZero\_Pressure() function. Check for the return status of type "CompStatus\_Enum" to ensure it is the same as "COMPINIT\_OK".
- 7. Read the raw pressure and temperature data from the sensor, pass the same as parameters to the Compensate\_Pressure() function. Check "CompReturn\_Struct.CompStatus" returned is PRESSURE\_VALID and get the compensated pressure data from "CompReturn\_Struct. f32PressureOutput".

# NOTICE

Initialization of the "Pressure\_Comp" module is done by calling the Compensate\_Pressure\_Init() function prior to calling the Compensate\_Pressure() function. If the initialization is not successful the same status is outputted from the Compensate\_ Pressure() function. When the Compensate\_Pressure() function returns any status other than the PRESSURE\_VALID status, the output pressure data should be discarded and should not be processed further.

#### 4.5 Constraints

The following considerations must be met to ensure the compiler settings are set to achieve the data type sizes shown in Table 4-6. • Ensure the "float" data type is as per the IEEE 754 single-precision binary floating-point format: binary32.

- Ensure the endianness of the microcontroller has been configured correctly in the "Pressure\_Comp.h" function.
- Ensure the sample code has a minimum of 1 kB of RAM for its operation.

#### Table 4-6. Data Type Sizes

Size
1 byte
4 byte (IEEE754)
2 byte
4 byte



Set the endianness of the processor/controller where the sample code is planned to be integrated in "Pressure\_Comp.h" file

# NOTICE

The sample code provided has been tested on a limited number of microcontrollers and compliers to ensure proper functionality on a well defined/designed target system. The application developer needs to ensure compiler dependence as well as compatibility of the code with target environment.

#### 5.0 SENSOR OFFSET ZERO CORRECTION PROCEDURE

Offset correction is a compensation technique based on sampling the output at a known reference condition within the compensated temperature and compensated pressure range of the sensor. Typically, a zero pressure reference, such as atmospheric pressure (or equal pressures on both pressure ports for a differential device), is used to allow the external correction of the offset error. Use the following sequence:

- 1. Set the sensor to zero pressure.
- 2. Measure  $P_{raw}$  and  $T_{raw}$  at a known zero reference ( $P_{raw0}$ ,  $T_{raw0}$ , for example).
- 3. Calculate  $P_{raw_{-A} Zero} = (OffsetCoefficient_2 * T_{raw_0}^3 + OffsetCoefficient_2 * T_{raw_0}^2 + OffsetCoefficient_1 * T_{raw_0} + OffsetCoefficient_0) P_{raw_0}^2$
- 4. Add the P<sub>raw\_AZero</sub> value to all P<sub>raw</sub> values for use in the standard algorithm (see Section 1.3)
- 5. Calculate P<sub>int1</sub> and P<sub>int2</sub> as usual but use the modified P<sub>raw</sub> values.

### ADDITIONAL INFORMATION

The following associated literature is available on the Honeywell web site at sps.honeywell.com/ast:

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Honeywell Advanced Sensing Technologies 830 East Arapaho Road Richardson, TX 75081 sps.honeywell.com/ast

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