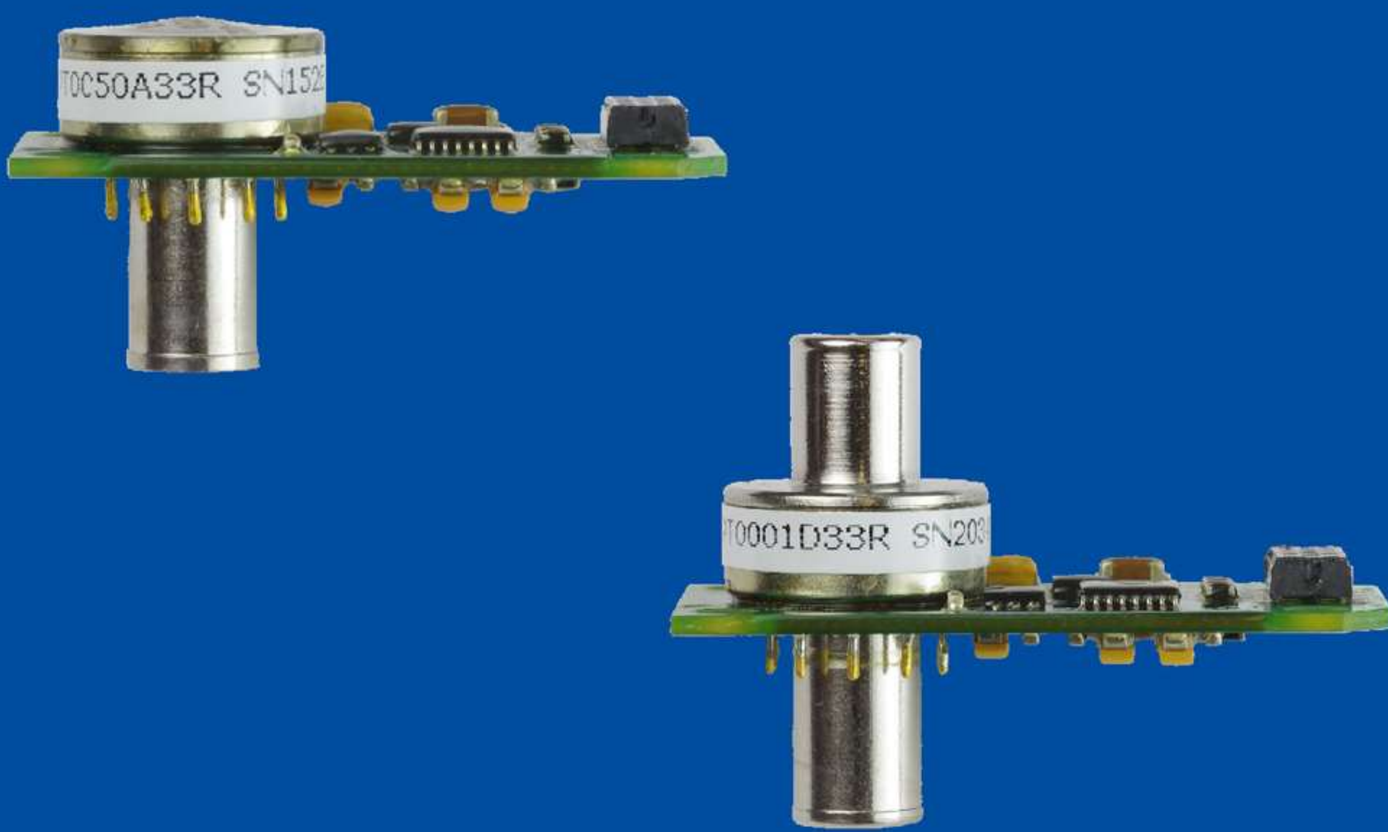
Honeywell Integrated Pressure Transducer



IPT User's Manual

Honeywell

ADS-14152 Rev. 7/16
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IPT User's Manual Contents

1 Introduction

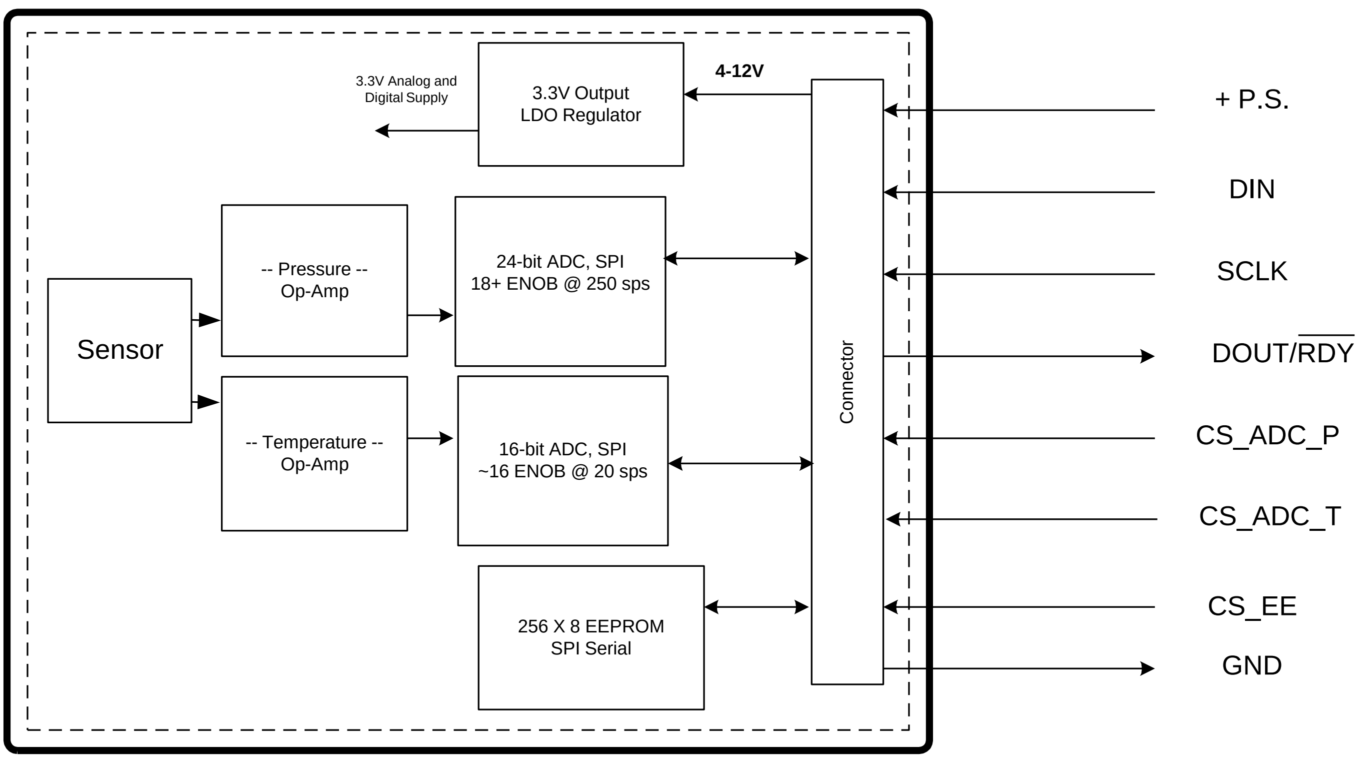
1.1 Overview

The Honeywell IPT provides high accuracy pressure data in an industry standard SPI digital format. The core of the IPT is a proven Honeywell silicon piezo-resistive pressure sensor with both pressure and temperature sensitive elements. The IPT is both small and lightweight and can be easily integrated into a wide variety of applications that require high performance in a small package.

Applying coefficients stored in the on-board EEPROM to normalized IPT pressure and temperature output yields accurate pressure readings over a -40 to 85°C compensated temperature range.

2 Specifications

2.1 Block Diagram

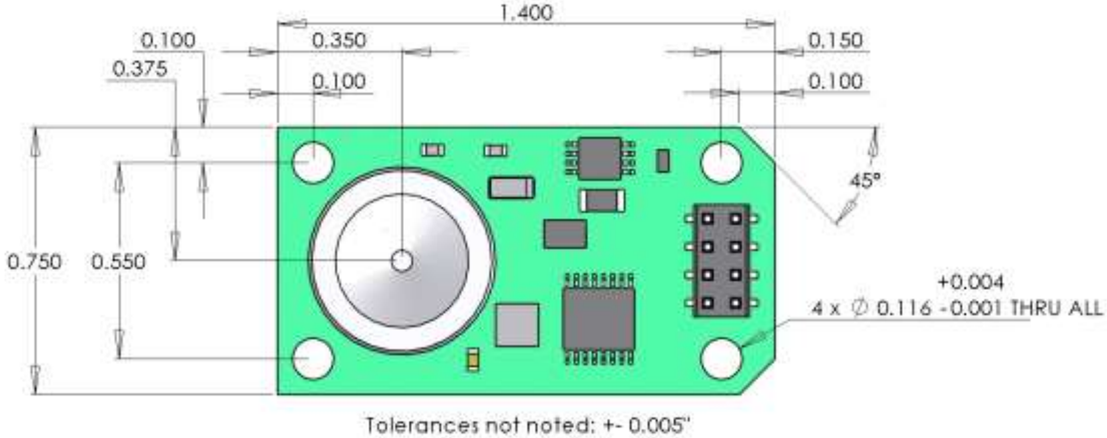


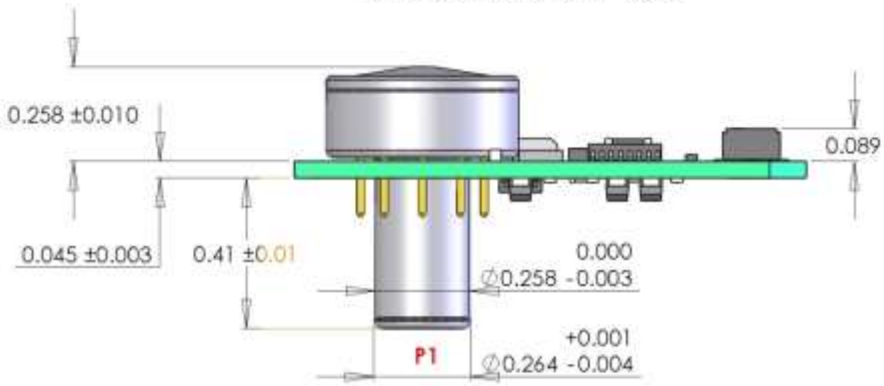
2.2 Specifications/Performance

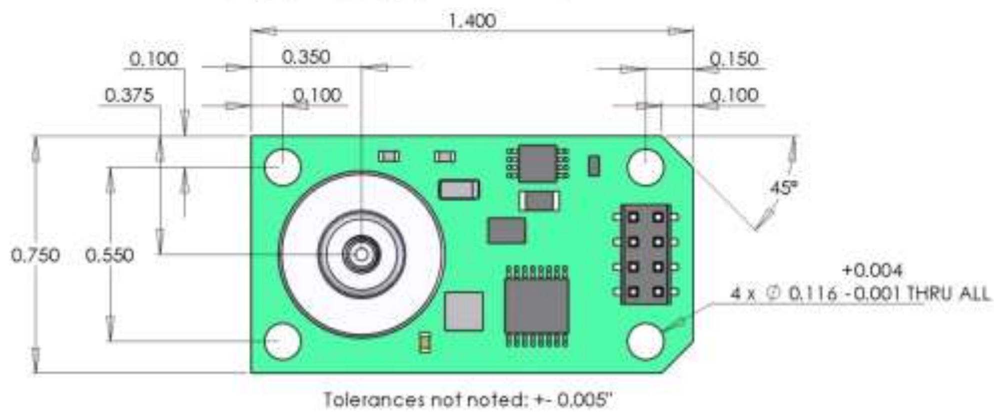
Total Error Band[1]	±0.04%FS absolute ±0.10%FS gauge, differential ±0.20%FS 1 psi gauge
Supply Voltage	4 to 12 VDC
Current Consumption	6 mA typical, 7.5 mA max
Operating Temperature Range	-40 to 85°C (-40 to 185°F)
Storage Temperature Range	-55 to 125°C (-67 to 257°F)
Sample Rate	See section 3.1.2
Long Term Stability	0.025%FS max per year typical
Pressure Ranges/Type	20, 50 psia 1, 2, 5, 10, 20 psig 1, 2, 5, 10, 20 psid
Pressure Units	PSI [2]
Media Compatibility	Non-condensing, non-corrosive, non-combustible gases
Weight [3]	~ 8.0 grams (absolute) ~ 9.7 grams (gauge, differential)
Size	See section 2.3 [3]
Interface	3.3V SPI (mode 1,1) [4] SCLK ≤ 5 MHz
Output	24-bit pressure value 16-bit temperature value 256 x 8 EEPROM configuration
Overpressure	3X FS
Burst Pressure	3X FS
Humidity Sensitivity of *Pressure Ports*	DO-160E, Section 6.0, category A [5]
Electromagnetic Immunity/Emissions	[6]
Mechanical Shock	DO-160E Section 7.0, Category A, Figure 7.2, Operational Standard
Thermal Variation	Storage Temperature Cycling per JESD22-104, Section 5.0: -55°C to +125°C,
Vibration	DO-160E Section 8, Category H, Aircraft Type 2, Aircraft Zones 1 & 2.
ESD	Class 3A, Table III, MIL-STD-883G, Method 3015.7, section 3.4
RoHS Compliant (2011/65/EU)	Yes

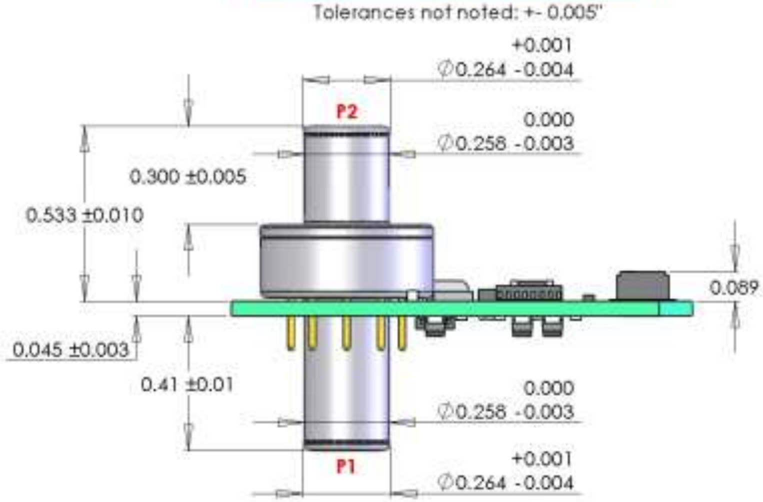
(1) Total Error is the sum of worst case linearity, repeatability, hysteresis, thermal effects, and calibration errors over the operating temperature range. Accuracy is only achieved after applying the correction coefficients and algorithm as shown in section 3.2. (FS = Full Scale) For total error calculations of differential units, “Full Scale” is the pressure difference between the minimum and maximum pressures. For example, full scale for a 1 psid PPT is 2 psi (-1 to +1 psi).
(2) After applying the correction coefficients stored in EEPROM, the resultant pressure reading is expressed in PSI (pounds per square inch).
(3) Not including any mounting hardware. Dimensions in section 2.3 do not include Humiseal 1A33 conformal coating which is typically applied to the PWB assembly at a thickness of 1-3 mils.
(4) Operation with a digital interface > 3.3V can damage the IPT and cause shifts in the ADC output.
(5) IPT electronics require protection from humidity.
(6) IPT requires shielding from EMI.

2.3 Outline/Dimensions (inches)









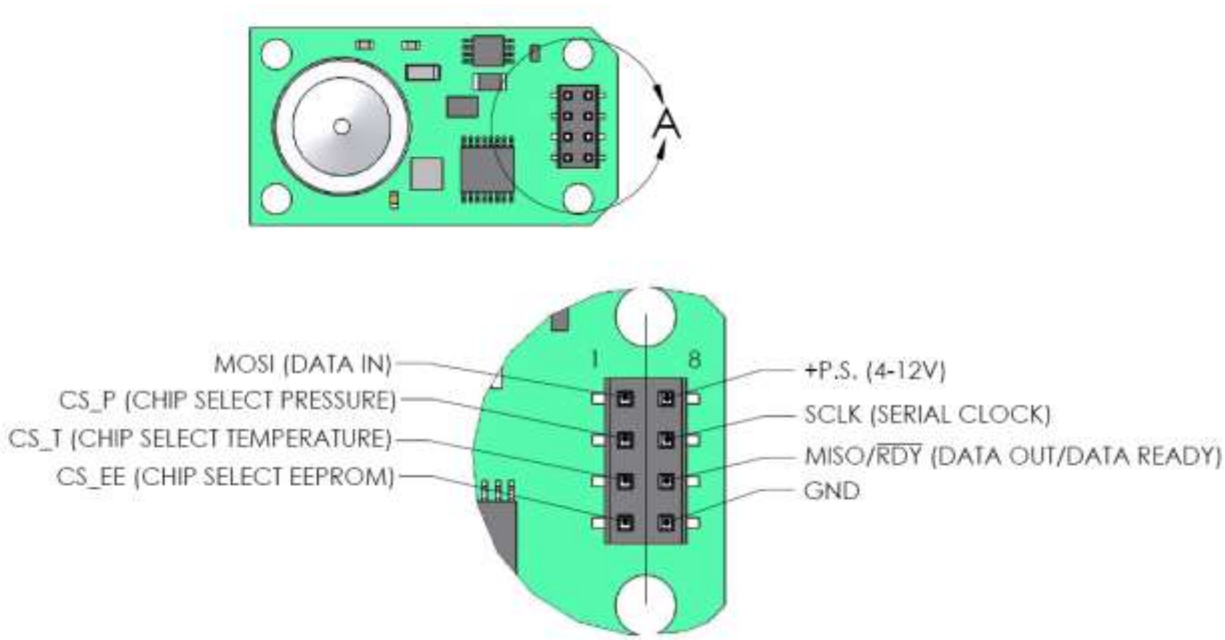
2.4 Electrical Connections

2.4.1 Connector

2mm, 2x4 Low Profile *Bottom & Top-Entry* Connector, Samtec P/N CLT-104-02-L-D-A-K-TR

Connector centered on circuit board and aligned with mounting holes.

Compatible Samtec mating connectors: TMM, MMT, TW, TMMH, MTMM



3 Operation

3.1 Commands and Format

3.1.1 Initialization

The IPT piezo-resistive pressure sensing die contains two bridge circuits; one for pressure, one for temperature. The IPT provides two serial (SPI-compatible) Analog-to-Digital Converters (ADCs), one for each of these data channels. The pressure channel uses a 24-bit ADC from Analog Devices, P/N AD7799. The temperature channel uses a 16-bit ADC from Analog Devices, P/N AD7790. After applying power to the IPT and before obtaining data, each data channel needs to be initialized.

As per the manufacturer's data sheets, the SPI serial clock for each ADC should be ≤ 5 MHz. During reads and writes to the ADC's as detailed below, the appropriate chip-select line must be brought low (CS_P or CS_T).

3.1.1.1 Pressure Channel

The pressure channel ADC is controlled and configured via a number of on-chip registers. ALL communication to the pressure channel ADC starts with a write operation to the 8-bit write-only communication register.
Initializing the pressure channel ADC requires writing data to a sequence of four registers; the Communication register, the Mode register, the Communication register, and the Configuration register.

3.1.1.1.1 Communication Register

Sending `0x10` to the Communication register tells the ADC the following write will be to the 16-bit Configuration register.

3.1.1.1.2 Configuration Register

Sending `0x1020` to the Configuration register sets the ADC's gain and buffering.

3.1.1.1.3 Communication Register

Sending `0x08` to the Communication register tells the ADC the following write will be to the 16-bit Mode register.

3.1.1.1.4 Mode Register

Sending `0x3001` to the Mode register places the ADC into a single conversion mode and sets the update rate, f_{ADC} to 470 Hz.

From the AD7799 manufacturer's datasheet:

"When single-conversion mode is selected, the ADC powers up and performs a single conversion. The oscillator requires 1 ms to power up and settle. The ADC then performs the conversion, which takes a time of $2/f_{ADC}$ **[4.26 ms]***. The conversion result is placed in the data register, $\overline{RDY}$ goes low, and the ADC returns to power-down mode. The conversion remains in the data register and $\overline{RDY}$ remains active (low) until the data is read or another conversion is performed."*

3.1.1.1.5 Reading

Note: after initialization is complete, reading the Configuration and Mode Registers is recommended to ensure they have been set as desired. See the AD7799 manufacturer's datasheet for information regarding reads of the Configuration and Mode registers.

3.1.1.2 Temperature Channel

The temperature channel ADC is controlled and configured via a number of on-chip registers. ALL communication to the temperature channel ADC starts with a write operation to the 8-bit write-only Communication register.
Initializing the temperature channel ADC requires writing data to a sequence of four registers; the Communication register, the Mode register, the Communication register, and the Filter register.

3.1.1.2.1 Communication Register

Sending `0x20` to the communication register tells the ADC the following write will be to the 8-bit Filter register.

3.1.1.2.2 Filter Register

Sending `0x03` to the Filter register sets the ADC's update rate (f_{ADC}) to 20 Hz.

3.1.1.2.3 Communication Register

Sending `0x10` to the Communication register tells the ADC the following write will be to the 8-bit Mode register.

3.1.1.2.4 Mode Register

Sending `0x80` to the Mode register places the ADC into a single conversion mode.

From the AD7790 manufacturer's datasheet:

"When single conversion mode is selected, the ADC powers up and performs a single conversion, which occurs after a period $2/f_{ADC}$ **[100 ms]***. The conversion result in placed in the data register, $\overline{RDY}$ goes low, and the ADC returns to power-down mode. The conversion remains in the data register and $\overline{RDY}$ remains active (low) until the data is read or another conversion is performed."*

3.1.1.2.5 Reading

Note: after initialization is complete, reading the Filter and Mode registers is recommended to ensure they have been set as desired. See the AD7790 manufacturer's datasheet for information regarding reads of the Filter and Mode registers.

3.1.2 Normal Operation (Polling)

3.1.2.1 Pressure Channel

After initializing the Mode register per section 3.1.1.2, a new 24-bit pressure value will be available in ~ 5.26 ms (1 ms settle time + 4.26 ms conversion).
The pressure conversion remains in the data register and DOUT/ $\overline{\text{RDY}}$ remains active (low) until the data is read or another conversion is performed.

The process of reading the conversion and reconfiguring the ADC for single conversion mode requires repeated cycling through the following steps:

1. Wait > 5.26 ms for the conversion to complete, and/or monitor the status of the DOUT/ $\overline{\text{RDY}}$ line.
2. Send `0x58` to the Communications register to indicate a subsequent read of the 24-bit Data register.
3. Send 24 clock cycles to read the 24-bit Data register.
4. Send `0x08` to the Communications register to indicate a subsequent write to the 16-bit Mode register.
5. Send `0x3001` to the Mode register to place the ADC into a single conversion mode and set the update rate to 470 Hz.
6. Repeat

3.1.2.1 Temperature Channel

After initializing the Mode register per section 3.1.1.1, a new 16-bit temperature value will be available in ~ 100 ms. (As temperature is generally a more slowly changing input than pressure, and has a modest impact on the pressure output, this conversion rate should be adequate for most applications.)
The temperature conversion remains in the data register and DOUT/ $\overline{\text{RDY}}$ remains active (low) until the data is read or another conversion is performed.

The process of reading the conversion and reconfiguring the ADC for single conversion mode requires repeated cycling through the following steps:

1. Wait 100 ms for the conversion to complete and/or monitor the status of the DOUT/ $\overline{\text{RDY}}$ line.
2. Send `0x38` to the Communications register to indicate a subsequent read of the 16-bit Data register.
3. Send 16 clock cycles to read the 16-bit Data register.
4. Send `0x10` to the Communications register to indicate a subsequent write to the 8-bit Mode register.
5. Send `0x80` to the Mode register to place the ADC into a single conversion mode.
6. Repeat

3.1.3 Other Modes

The Honeywell IPT has been tested using the “Initialization” and “Normal Polling” as described in sections 3.1.1 and 3.1.2. above.

Both pressure and temperature channel ADCs may also be configured to operate in Continuous Conversion and Continuous Reads modes. Performance should be substantially the same in these alternate modes. However, they have not been thoroughly tested.

3.2 Correction Algorithms

3.2.1 Pressure

One of 2 similar algorithms for converting IPT temperature and pressure channel ADC values into corrected pressure readings is identified for each IPT. (Section 3.3.2.7 describes how the applicable algorithm identity is documented in the IPT EEPROM contents.)

Coefficients (A, a1, a2, etc.) for the identified algorithm are stored in the IPT EEPROM. The algorithm result (Y) is a corrected pressure reading in pounds per square inch (PSI). ADC values from the temperature channel (normalized) are used to correct the readings for thermal effects.

3.2.1.1 Algorithm #1

$$Y = A + (F1 \times p) + (F2 \times p^2) + (F3 \times p^3) + (F4 \times p^4) + (F5 \times p^5) + (F6 \times p^6)$$

Where:

$$F1 = a1 + (b1 \times t) + (c1 \times t^2) + (d1 \times t^3) + (e1 \times t^4) + (fa1 \times t^5)$$
$$F2 = a2 + (b2 \times t) + (c2 \times t^2) + (d2 \times t^3) + (e2 \times t^4) + (fa2 \times t^5)$$
$$F3 = a3 + (b3 \times t) + (c3 \times t^2) + (d3 \times t^3) + (e3 \times t^4) + (fa3 \times t^5)$$
$$F4 = a4 + (b4 \times t) + (c4 \times t^2) + (d4 \times t^3) + (e4 \times t^4) + (fa4 \times t^5)$$
$$F5 = a5 + (b5 \times t) + (c5 \times t^2) + (d5 \times t^3) + (e5 \times t^4) + (fa5 \times t^5)$$
$$F6 = a6 + (b6 \times t) + (c6 \times t^2) + (d6 \times t^3) + (e6 \times t^4) + (fa6 \times t^5)$$

Output: **Y** = pressure value in PSI

Inputs: **p** = 24-bit pressure channel ADC value, normalized 0 – 1
Normalized pressure channel ADC value = pressure channel ADC value / 16,777,215

t = 16-bit temperature channel ADC value, normalized 0 - 1
Normalized temperature channel ADC value = temperature channel ADC value / 65,535

3.2.1.1.1 Horner's Method, Algorithm #1

Horner's method is a suggested microcontroller-friendly alternative for evaluating the above equations:

Y = A + p(F1 + p(F2 + p(F3 +p(F4 + p(F5 + p(F6))))))	**(6 multiplies, 6 additions)**
F1 = a1 + t(b1 + t(c1 + t(d1 + t(e1 + t(fa1)))))	**(5 multiplies, 5 additions)**
F2 = a2 + t(b2 + t(c2 + t(d2 + t(e2 + t(fa2)))))	**(5 multiplies, 5 additions)**
F3 = a3 + t(b3 + t(c3 + t(d3 + t(e3 + t(fa3)))))	**(5 multiplies, 5 additions)**
F4 = a4 + t(b4 + t(c4 + t(d4 + t(e4 + t(fa4)))))	**(5 multiplies, 5 additions)**
F5 = a5 + t(b5 + t(c5 + t(d5 + t(e5 + t(fa5)))))	**(5 multiplies, 5 additions)**
F6 = a6 + t(b6 + t(c6 + t(d6 + t(e6 + t(fa6)))))	**(5 multiplies, 5 additions)**
Total:	**36 multiplies, 36 additions**

3.2.1.2 Algorithm #2

Differences from Algorithm #1 are highlighted in blue

$$Y = A + (F1 \times p) + (F2 \times p^2) + (F3 \times p^3) + (F4 \times p^4) + (F5 \times p^5) + F6$$

Where:

$$F1 = a1 + (b1 \times t) + (c1 \times t^2) + (d1 \times t^3) + (e1 \times t^4) + (fa1 \times t^5)$$
$$F2 = a2 + (b2 \times t) + (c2 \times t^2) + (d2 \times t^3) + (e2 \times t^4) + (fa2 \times t^5)$$
$$F3 = a3 + (b3 \times t) + (c3 \times t^2) + (d3 \times t^3) + (e3 \times t^4) + (fa3 \times t^5)$$
$$F4 = a4 + (b4 \times t) + (c4 \times t^2) + (d4 \times t^3) + (e4 \times t^4) + (fa4 \times t^5)$$
$$F5 = a5 + (b5 \times t) + (c5 \times t^2) + (d5 \times t^3) + (e5 \times t^4) + (fa5 \times t^5)$$
$$F6 = a6 + (b6 \times t) + (c6 \times t^2) + (d6 \times t^3) + (e6 \times t^4) + (fa6 \times t^5)$$

Output: **Y** = pressure value in PSI

Inputs: **p** = 24-bit pressure channel ADC value, normalized 0 – 1
Normalized pressure channel ADC value = pressure channel ADC value / 16,777,215

t = 16-bit temperature channel ADC value, normalized 0 - 1
Normalized temperature channel ADC value = temperature channel ADC value / 65,535

3.2.1.2.1 Horner's Method, Algorithm #2

Horner's method is a suggested microcontroller-friendly alternative for evaluating the above equations:

Y = A + p(F1 + p(F2 + p(F3 +p(F4 + p(F5))))) + F6 **(5 multiplies, 6 additions)**

F1 = a1 + t(b1 + t(c1 + t(d1 + t(e1 + t(fa1))))) **(5 multiplies, 5 additions)**

F2 = a2 + t(b2 + t(c2 + t(d2 + t(e2 + t(fa2))))) **(5 multiplies, 5 additions)**

F3 = a3 + t(b3 + t(c3 + t(d3 + t(e3 + t(fa3))))) **(5 multiplies, 5 additions)**

F4 = a4 + t(b4 + t(c4 + t(d4 + t(e4 + t(fa4))))) **(5 multiplies, 5 additions)**

F5 = a5 + t(b5 + t(c5 + t(d5 + t(e5 + t(fa5))))) **(5 multiplies, 5 additions)**

F6 = a6 + t(b6 + t(c6 + t(d6 + t(e6 + t(fa6))))) **(5 multiplies, 5 additions)**

Total: 35 **multiplies**, 36 additions

3.2.2 Pressure Sensor Temperature

Starting in the May 2011 timeframe, coefficients for converting 16-bit Pressure Sensor Temperature values to °C have been appended to the EEPROM contents of new IPT transducers. This supplemental information allows users, if desired, to separately monitor the temperature of the pressure sensor. The algorithm is a simple 3rd order polynomial as described below:

3.2.2.1 Algorithm

$$\mathbf{Y = g1 + (g2 \times t) + (g3 \times t^2) + (g4 \times t^3)}$$

Output: **Y** = pressure sensor temperature in °C

Inputs: **t** = 16-bit temperature channel ADC value, normalized 0 – 1:

Normalized temperature channel ADC value = temperature channel ADC value / 65,535

Coefficients (g1, g2, g3 and g4) for the identified algorithm are stored in the IPT EEPROM.

3.2.2.1.1 Horner's Method

Horner's method is a suggested microcontroller-friendly alternative for evaluating the above equation:

$$\mathbf{Y = g1 + t(g2 + t(g3 + t(g4)))} \qquad \textbf{(3 multiplies, 3 additions)}$$

3.3 EEPROM Storage

3.3.1 EEPROM Format

The IPT transducer uses a 2 Kbit serial EEPROM from Microchip, P/N 25LC020AT-E/MC.
The EEPROM is organized as 256 x 8. Reads/writes to the EEPROM should be per the manufacturer's data sheet. Note: values are stored "big-endian"; most significant bit first.

3.3.2 Contents

3.3.2.1 Pressure Correction Coefficients

The 37 correction coefficients (`A` through `fa6`) are stored in 32-bit IEEE 754 format in locations `00` through `93`.

Example: `-7.2467064 = C0E7E504`

3.3.2.2 Full Scale Pressure Range

The IPT full scale pressure range (`FS`) is stored in 32-bit IEEE 754 format in locations `94` through `97`.

Example: `20 = 41A00000`

3.3.2.3 Minimum/Maximum Operating/Storage Temperature Limits

IPT operating/storage temperature limits (`Min/Max Op/Stor Temp`) are stored as 8-bit signed integers in locations `98` through `9B`.

Examples:	Min Operating	`-40 = D8`
	Max Operating	`85 = 55`
	Min Storage	`-55 = C9`
	Max Storage	`125 = 7D`

3.3.2.4 Minimum Pressure Output

The minimum pressure output value (`Pmin`) is the minimum value observed from the pressure channel ADC over the IPT operating temperature/pressure range and is stored as a 24-bit unsigned integer. Location `9C` is padded with `00` and `Pmin` is stored in locations `9D` through `9F`.

Example: `1213487 = 12842F`

3.3.2.5 Maximum Pressure Output

The maximum pressure output value (`Pmax`) is the maximum value observed from the pressure channel ADC over the IPT operating temperature/pressure range and is stored as a 24-bit unsigned integer. Location `A0` is padded with `00` and `Pmax` is stored in locations `A1` through `A3`.

Example: `11021407 = A82C5F`

Note: These values can be used to determine if the IPT is being used within its specified operating range. If samples from the pressure ADC are outside this range, the accuracy of the correction algorithm cannot be guaranteed.

3.3.2.6 Minimum/Maximum Temperature Output

The minimum and maximum temperature output values (`Min/Max Tout`) are the minimum and maximum values observed from the temperature channel ADC over the IPT operating temperature/pressure range and are stored as 16-bit unsigned integers. The minimum value is stored in locations `A4` through `A5` and the maximum value in `A6` through `A7`.

Examples:	Min	`40175 = 9CEF`
	Max	`60503 = EC57`

Note: These values can be used to determine if the IPT is being used within its specified operating range. If samples from the temperature ADC are outside this range, the accuracy of the correction algorithm cannot be guaranteed.

3.3.2.7 Algorithm/Type, Date

Four unsigned bytes are used to identify the correction Algorithm, IPT transducer Type and the manufacturing Date Code (`Algorithm/Type/Date Code`) at locations `A8` through `AB`.

The most significant byte is used to identify both the correction Algorithm and IPT type with high nibble for Algorithm and low nibble for Type (shown here in binary).

Algorithm is:	#1	`= 0000b`
	#2	`= 0001b`
Type is defined as:	Absolute	`= 0001b`
	Gauge	`= 0010b`
	Differential	`= 0011b`

Date is stored using the three remaining bytes in the format of mmddyy.

Example: `010C1B07` = Algorithm #1, Absolute, December 27, 2007
Example: `13060B0A` = Algorithm #2, Differential, June 11, 2010

3.3.2.8 Serial Number

The IPT' serial number (`Serial No.`) is stored as an unsigned 32-bit value in locations `AC` through `AF`.
Example: `1100009827 = 4190D163`

3.3.2.9 Honeywell Part Number

The Honeywell part number (`Hon. P/N`) stored in EEPROM is encoded to form a P/N in the form of 22xxxxxx-0xx or 58xxxxxx-xxx with a special-order code of –Tyyy.

xxxxxxxx is 24-bit unsigned value from `000000` to `16777215` and yyy is an 8-bit unsigned value from `00` to `255`.

xxxxxxxx is stored in locations B0 through B2. yyy is stored in location B3.

Examples:

2FDDE901 = Honeywell Part Number 22031370-001
Special-order code –T001.

37107D07 = Honeywell Part Number 58036087-001
Special-order code –T007.

3.3.2.10 Checksum Bytes

Two checksum bytes (Checksum Bytes) are stored in locations B4 and B5. The checksum bytes are stored such that an 8-bit Fletcher checksum calculation (Modulo 256) on the primary storage area (00 through B5) yields a zero for each of the calculated 8-bit Fletcher Checksum values.
In the case of the example Table 1 below, the checksum bytes are B4 and 64.
See section 6 for a description of the Fletcher Checksum.

3.3.2.11 **Supplemental Information:** Pressure Sensor Temperature to °C Coefficients

The 4 correction coefficients (g1 through g4) are stored in 32-bit IEEE 754 format in locations B8 through C7.

Example: -1796.9403 = C4E09E17

3.3.2.12 **Supplemental Information:** "Seed" Values and Corresponding Corrected Pressure

To aid in development and debug of the Pressure Correction Algorithms found in section 3.2.1, a transducer-specific 24-bit Seed Pressure Count (spc), a 16-bit Seed Temperature Count (stc) and the corresponding 32-bit IEEE 754 Corrected Seed Pressure reading (csp) have been stored in the IPT EEPROM:

The 24-bit spc value is stored in locations C8 through CB with leading zero's.
The 16-bit stc value is stored in locations CC through CF with leading zero's.
The 32-bit csp value is stored in locations DO through D3 in IEEE 754 format.

3.3.2.13 **Supplemental Information:** Checksum Bytes

Two checksum bytes (Checksum Bytes) are stored in locations D4 and D5. The checksum bytes are stored such that an 8-bit Fletcher checksum calculation (Modulo 256) on the supplemental storage area (B8 through D5) yields a zero for each of the calculated 8-bit Fletcher Checksum values.
In the case of the example Table 1 below, the supplemental checksum bytes are CB and 1A. See section 6 for a description of the Fletcher Checksum.

3.3.2.14 Unused Locations

Locations B6, B7 and D6 through FF are unused and available for storage of customer information.

Table 1. EEPROM Map w/ Example Values

Description	Inputs					ADDR	Stored Values			
A	-10.251645					00	C1	24	06	BD
a1	-1796.9403					04	C4	E0	9E	17
a2	-4162.3979					08	C5	82	13	2F
a3	6.8445935					0C	40	DB	06	E9
a4	-2651.1321					10	C5	25	B2	1D
a5	-5778.0547					14	C5	B4	90	70
a6	10801.397					18	46	28	C5	97
b1	14889.769					1C	46	68	A7	13
b2	18248.301					20	46	8E	90	9A
b3	20223.174					24	46	9D	FE	59
b4	-4042.4363					28	C5	7C	A6	FB
b5	66986.164					2C	47	82	D5	15
b6	-93110.602					30	C7	B5	DB	4D
c1	-46230.684					34	C7	34	96	AF
c2	-28188.965					38	C6	DC	39	EE
c3	-83723.297					3C	C7	A3	85	A6
c4	20603.07					40	46	A0	F6	24
c5	-216138.38					44	C8	53	12	98
c6	295352.34					48	48	90	37	0B
d1	70067.305					4C	47	88	D9	A7
d2	20100.578					50	46	9D	09	28
d3	107100.88					54	47	D1	2E	71
d4	45148.465					58	47	30	5C	77
d5	268675.63					5C	48	83	30	74
d6	-438418.22					60	C8	D6	12	47
e1	-51952.816					64	C7	4A	F0	D1
e2	-10252.898					68	C6	20	33	98
e3	-31521.736					6C	C6	F6	43	79
e4	-148898.56					70	C8	11	68	A4
e5	-108588.63					74	C7	D4	16	50
e6	306424.84					78	48	95	9F	1B
fa1	15124.948					7C	46	6C	53	CB
fa2	4531.3633					80	45	8D	9A	E8
fa3	-13495.57					84	C6	52	DE	48
fa4	92770.586					88	47	B5	31	4B
fa5	-7349.3057					8C	C5	E5	AA	72
fa6	-80684.555					90	C7	9D	96	47
FS	50					94	42	48	00	00
Min/Max Op/Stor Temp	-40	85	-55	125		98	D8	55	C9	7D
Pmin	2336726					9C	00	23	A7	D6
Pmax	13173153					A0	00	C9	1	A1
Min/Max Tout	39393	50413				A4	99	E1	C4	ED
Algorithm/Type, Date Code	1	7	31	10		A8	01	07	1F	0A
Serial No.	1464					AC	00	00	05	B8
Hon. P/N	3137201	0				B0	2F	DE	B1	00
Checksum Bytes	byte1	byte2				B4	B4	64		
g1	-2882.41					B8	C5	34	26	8F
g2	11581.7					BC	46	34	F6	CD
g3	-16459.2					C0	C6	80	96	66
g4	8494.38					C4	46	04	B9	85
spc	10086589					C8	00	99	E8	BD
stc	41487					CC	00	00	A2	0F
csp	13.9968					DO	41	5F	F2	E5
Checksum Bytes	byte1	byte2				D4	CB	1A		

4 Installation Recommendations

1. IPT media compatibility is non-condensing, non-corrosive, non-combustible gases. To ensure the best transducer performance it is strongly suggested that IPT transducers and associated plumbing be oriented to prevent accumulation of debris or condensation in the pressure ports.

2. Pressure ports P1 and P2 should be shielded from direct light due to a strong photoelectric effect on the sense element.

3. Although conformally coated, electronics should be protected from humidity exposure.

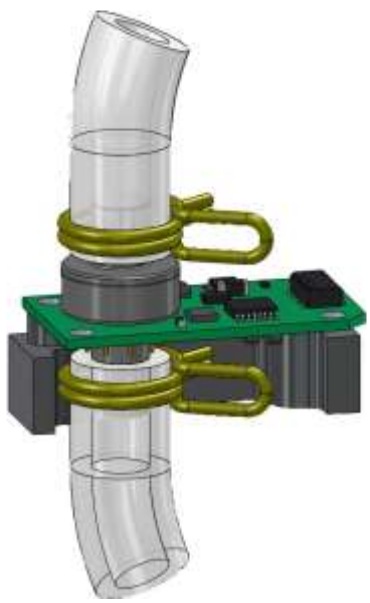
4. Transducer should be mounted to minimize mechanical stress between circuit board and on-board pressure sensor.

5. Although there is no official specification for the SPI interface (a defacto standard), it is intended for short distance on-board communications between a microcontroller or microprocessor (Master) and a peripheral (Slave). To help ensure signal integrity, minimize signal path distance between any Master and the IPT.

4.1 Installation Examples

The three examples below are for illustrative purposes only and do not represent all possible methods of installing the IPT.

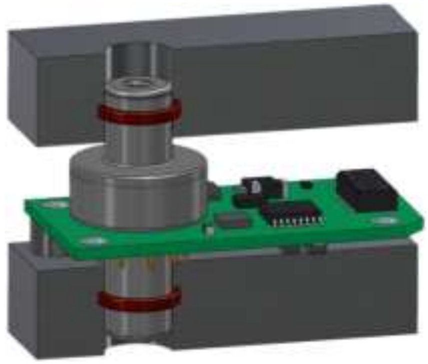
4.1.1 Flexible Tubing and Double-wire Hose Clamps



Considerations:

1. Select tubing size/material for the application's temperature and pressure extremes.
2. Ensure hose clamps do no contact any IPT circuitry.
3. Shield port P2 from light due to strong photoelectric effect upon the sense element.
4. Minimize mechanical stress between the circuit board and the on-board pressure sensor.

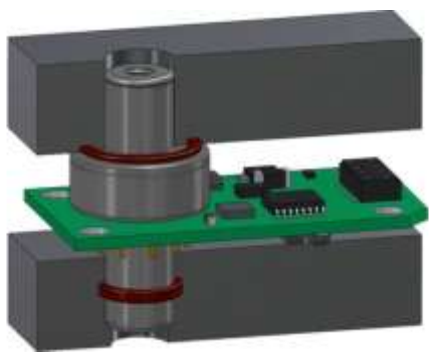
4.1.2 Static Radial O-ring Seals



Considerations:

1. Select o-ring size/material for the application’s temperature and pressure extremes.
2. Minimize mechanical stress between the circuit board and the on-board pressure sensor.

4.1.3 Static Radial and Face O-ring Seals



Considerations:

1. Select o-ring size/material for the application’s temperature and pressure extremes.
2. Minimize mechanical stress between the circuit board and the on-board pressure sensor.

5 Marking

An adhesive label on the O.D. of the IPT sensor contains the unit’s model code, serial number, and date code (MMDDYY).

Example: **`IPT0020A33R-T003 S/N 2376 081710`**

6 Fletcher Checksum

6.1 Calculation

The Fletcher checksum calculation results in two sums:

SUM1[R-1] = D[0] + D[1] + …D[R-1]
SUM2[R-1] = SUM1[0] + SUM1[1] + …SUM1[R-1]

where R = number of bytes in the EEPROM storage area from 00 through B5 (182d), including the check bytes, and where all additions are modulo 256.

If no errors are found, SUM1[R-1] = SUM2[R-1] = 0

Example: 4 bytes of data, 2 check bytes, no errors

	Hex	Binary	Decimal	SUM1	SUM2
Data	C0	11000000	192	192	192
Data	E7	11100111	231	167	103
Data	E5	11100101	229	140	243
Data	04	00000100	4	144	131
Check Byte #1	ED	11101101	237	125	0
Check Byte #2	83	10000011	131	**0**	**0**

Example with single-bit error

	Hex	Binary	Decimal	SUM1	SUM2
Data	C0	11000000	192	192	192
Data	E7	11100111	231	167	103
Data	**C5**	11000101	197	108	211
Data	04	00000100	4	112	67
Check Byte #1	ED	11101101	237	93	160
Check Byte #2	83	10000011	131	**224**	**128**

Example with two single-bit errors

	Hex	Binary	Decimal	SUM1	SUM2
Data	**C2**	11000010	194	194	194
Data	**E5**	11100101	229	167	105
Data	E5	11100101	229	140	245
Data	04	00000100	4	144	133
Check Byte #1	ED	11101101	237	125	2
Check Byte #2	83	10000011	131	**0**	**2**

Example with multiple errors

	Hex	Binary	Decimal	SUM1	SUM2
Data	**64**	01100100	100	100	100
Data	E7	11100111	231	75	175
Data	E5	11100101	229	48	223
Data	**BC**	10111100	188	236	203
Check Byte #1	ED	11101101	237	217	164
Check Byte #2	83	10000011	131	**92**	**0**

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