

Miniature I²C Digital Barometer

The MPL115A2 is an absolute pressure sensor with digital output for low cost applications. A miniature 5 x 3 x 1.2 mm LGA package ideally suits it for portable electronics and space constrained applications. Low current consumptions of 5 μ A during Active mode and 1 μ A during Shutdown (Sleep) mode target battery and other low-power applications. A wide operating temperature range from -40°C to +105°C fits demanding environmental requirements.

MPL115A2 employs a MEMS pressure sensor with a conditioning IC to provide accurate pressure measurement from 50 to 115 kPa. An integrated ADC provides digitized temperature and pressure sensor outputs via an I²C port. Calibration Data is stored in internal ROM. Utilizing raw sensor output, the host microcontroller executes a compensation algorithm to render *Compensated Absolute Pressure* with 1 kPa accuracy.

The MPL115A2 pressure sensor's small form factor, low power capability, precision, and digital output optimize it for barometric measurement applications.

Features

- Digitized pressure and temperature information together with programmed calibration coefficients for host micro use.
- Factory Calibrated
- 50 kPa to 115 kPa Absolute Pressure
- 1 kPa Accuracy
- 2.375 V to 5.5 V Supply
- Integrated ADC
- I²C Interface
- Monotonic Pressure and Temperature Data Outputs
- Surface Mount RoHS Compliant Package

MPL115A2

50 to 115 kPa

Application Examples

- Barometry (portable and desk-top)
- Altimeters
- Weather Stations
- Hard Disk-Drives (HDD)
- Industrial Equipment
- Health Monitoring
- Air Control Systems

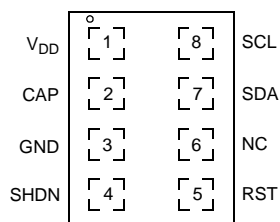
ORDERING INFORMATION

| Device Name | Package Options | Case No. | # of Ports | | | Pressure Type | | | Digital Interface |
|-------------|-----------------|----------|------------|--------|------|---------------|--------------|----------|-------------------|
| | | | None | Single | Dual | Gauge | Differential | Absolute | |
| MPL115A2T1 | Tape & Reel | 2015 | • | | | | | • | I ² C |

LGA PACKAGE



MPL115A2
5.0 mm X 3.0 mm X 1.2 mm MAX



PIN CONNECTIONS

Pin Description

| PIN | NAME | FUNCTION |
|-----|--------------------|---|
| 1 | VDD | VDD Power Supply Connection. |
| 2 | CAP | External Capacitor |
| 3 | GND | Ground |
| 4 | SHDN | Shutdown (Sleep): Connect to GND to disable the device. |
| 5 | RST | Reset: Drive line low to disable I ² C communications. |
| 6 | NC | NC: No connection. |
| 7 | SDA ⁽¹⁾ | SDA: Serial data I/O line. |
| 8 | SCL ⁽¹⁾ | I ² C Serial Clock Input. |

1. Use 4.7k pull-up resistors for I²C communication.

Maximum Ratings

Voltage (with respect to GND unless otherwise noted)

| | |
|--|--------------------------|
| V_{DD} | -0.3 V to +5.5 V |
| SCLK, \overline{CS} , D_{IN} , D_{OUT} | -0.3 V to $V_{DD}+0.3$ V |
| Operating Temperature Range | -40°C to +105°C |
| Storage Temperature Range..... | -40°C to +125°C |
| Overpressure | 1000 kPa |

Operating Characteristics

(V_{DD} = 2.375 V to 5.5 V, T_A = -40°C to +105°C, unless otherwise noted. Typical values are at $V_+ = 3.3$ V, $T_A = +25^\circ\text{C}$.)

| Ref | Parameters | Symbol | Conditions | Min | Typ | Max | Units |
|---|--|------------------|---|--------------------|---------|--------------------|---------------|
| 1 | Operating Supply Voltage | V_{DD} | | 2.375 | 3.3 | 5.5 | V |
| 2 | Supply Current | I_{DD} | Shutdown (SHDN = GND) | — | — | 1 | μA |
| | | | Standby | — | 3.5 | 10 | μA |
| | | | Average – at one measurement per second | — | 5 | 6 | μA |
| Pressure Sensor | | | | | | | |
| 3 | Range | | | 50 | — | 115 | kPa |
| 4 | Resolution | | | — | 0.15 | — | kPa |
| 5 | Accuracy | | -20°C to 85°C | — | ± 1 | — | kPa |
| 6 | Power Supply Rejection | | Typical operating circuit at DC | — | 0.1 | — | kPa/V |
| | | | 100 mV p-p 217 Hz square wave plus 100 mV pseudo random noise with 10 MHz bandwidth. | — | 0.1 | — | kPa |
| 7 | Conversion Time (Start Pressure Convert) | t _{cp} | Time between start convert command and data available in the Pressure register | — | 0.6 | 0.7 | ms |
| Temperature Sensor | | | | | | | |
| 8 | Range | | | -40 | — | 105 | °C |
| 9 | Conversion Time (Start Temperature Convert) | t _{ct} | Time between start convert command and data available in the Temperature register | — | 0.6 | 0.7 | ms |
| 10 | Conversion Time (Start Both Convert) | t _{cb} | Time between start convert command and data available in the Pressure and Temperature registers | — | 0.8 | 1 | ms |
| 11 | Resolution | | Temperature ADC is 472 counts at 25°C | — | -5.35 | — | counts/°C |
| I²C I/O Stages: SCL, SDA | | | | | | | |
| 12 | SCL Clock Frequency | f _{SCL} | | — | — | 400 | KHz |
| 13 | Low Level Input Voltage | V _{IL} | | — | — | 0.3V _{DD} | V |
| 14 | High Level Input Voltage | V _{IH} | | 0.7V _{DD} | — | — | V |
| I²C Outputs: SDA | | | | | | | |
| 15 | Data Setup Time | t _{SU} | Setup time from command receipt to ready to transmit | 100 | — | — | ns |
| I²C Addressing | | | | | | | |
| MPL115A2 uses 7-bit addressing, does not acknowledge the general call address 0000000. Slave address has been set to 0x60 or 1100000. | | | | | | | |

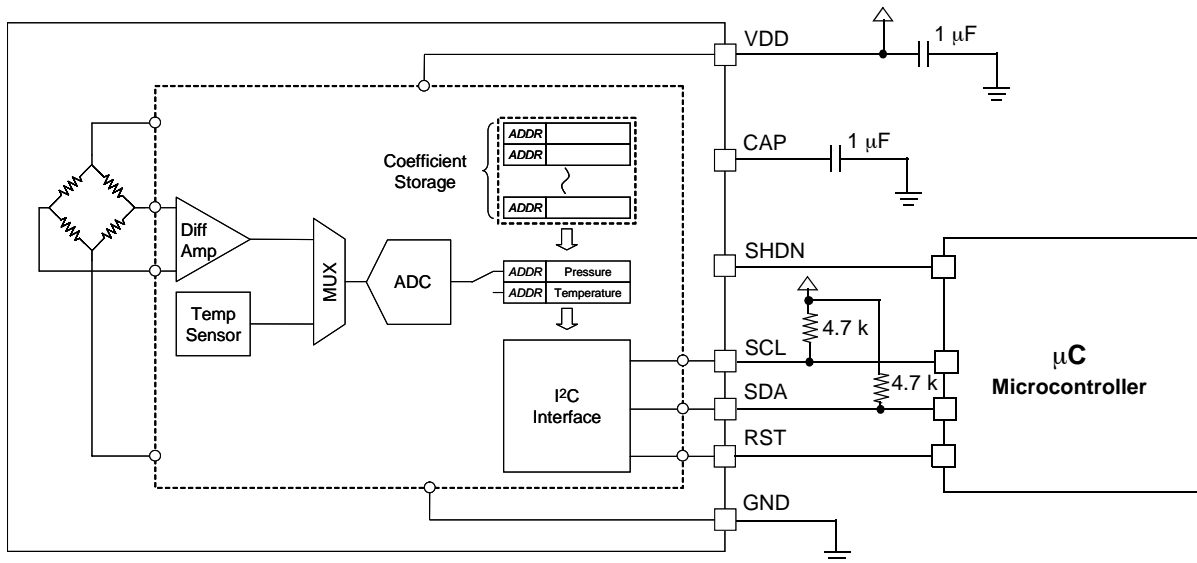


Figure 1. Block Diagram

Compensation

The pressure compensation for MPL115A2 is based on a 2-dimensional, second order polynomial.

The 10-bit compensated pressure output, P_{comp} , is calculated as follows:

$$P_{comp} = a_0 + (b_1 + c_{11} \cdot P_{adc} + c_{12} \cdot T_{adc}) \cdot P_{adc} + (b_2 + c_{22} \cdot T_{adc}) \cdot T_{adc}$$

Where:

- P_{adc} is the 10-bit pressure output of the MPL115A2 ADC,
- T_{adc} is the 10-bit temperature output of the MPL115A2 ADC,
- a_0 is the pressure offset coefficient,
- b_1 is the pressure sensitivity coefficient,
- c_{11} is the pressure linearity (2nd order) coefficient,
- c_{12} is the coefficient for temperature sensitivity coefficient (TCS),
- b_2 is the 1st order temperature offset coefficient (TCO),
- c_{22} is the 2nd order temperature offset coefficient.

Ideally, P_{comp} will produce a value of 0 with an input pressure of 50 kPa and will produce a full-scale value of 1023 with an input pressure of 115 kPa.

Coefficient Bit-Width Specs

The table below specifies the initial coefficient bit-width specs for the compensation algorithm.

| 10-bit Output: Compensation Coefficient Specs | | | | | | | Total Coeff. Bits |
|---|----|----|----|-----|------|------|-------------------|
| | a0 | b1 | b2 | c12 | c11* | c22* | |
| Total Bits | 16 | 16 | 16 | 14 | 11 | 11 | 84 |
| Sign Bits | 1 | 1 | 1 | 1 | 1 | 1 | |
| Integer Bits | 12 | 2 | 1 | 0 | 0 | 0 | |
| Fractional Bits | 4 | 13 | 14 | 13 | 11 | 10 | |
| dec pt zero pad | — | — | — | 9 | 11 | 15 | |

* Factory reserves the option to make these values = 0.

Example Binary Format Definitions:

- Sign = 0, Integer Bits = 8, Fractional Bits = 4 : Coeff = S $I_7 I_6 I_5 I_4 I_3 I_2 I_1 I_0 . F_3 F_2 F_1 F_0$
- Sign = 1, Integer Bits = 4, Fractional Bits = 7 : Coeff = S $I_3 I_2 I_1 I_0 . F_6 F_5 F_4 F_3 F_2 F_1 F_0$
- Sign = 0, Integer Bits = 0, Fractional Bits = 6, dec pt zero pad = 2 : Coeff = S 0 . 0 0 $F_5 F_4 F_3 F_2 F_1 F_0$
- Sign = 0, Integer Bits = 0, Fractional Bits = 5, dec pt zero pad = 3 : Coeff = S 0 . 0 0 0 $F_4 F_3 F_2 F_1 F_0$

NOTE: Negative coefficients (Sign = 1) are coded in 2's complement notation.

Coefficient Address Map

| Address | Coefficient |
|---------|-------------|
| \$04 | a0 MS Byte |
| \$05 | a0 LS Byte |
| \$06 | b1 MS Byte |
| \$07 | b1 LS Byte |
| \$08 | b2 MS Byte |
| \$09 | b2 LS Byte |
| \$0A | c12 MS Byte |
| \$0B | c12 LS Byte |
| \$0C | c11 MS Byte |
| \$0D | c11 LS Byte |
| \$0E | c22 MS Byte |
| \$0F | c22 LS Byte |

For coefficients with less than 16 bits, the lower lsbs are zero. For example, c11 is 11 bits and is stored into 2 bytes as follows:

$$c11 \text{ MS byte} = c11[10:3] = [c11_{b10}, c11_{b9}, c11_{b8}, c11_{b7}, c11_{b6}, c11_{b5}, c11_{b4}, c11_{b3}]$$

$$c11 \text{ LS byte} = c11[2:0] \& \text{"00000"} = [c11_{b2}, c11_{b1}, c11_{b0}, 0, 0, 0, 0, 0]$$

Solder Recommendations

1. Use SAC solder alloy (i.e., Sn-Ag-Cu) with a melting point of about 217°C. It is recommended to use SAC305 (i.e., Sn-3.0 wt.% Ag-0.5 wt.% Cu).
2. Reflow
 - Ramp up rate: 2 to 3 C/s.
 - Preheat flat (soak): 110 to 130s.
 - Reflow peak temperature: 250°C to 260°C (depends on exact SAC alloy composition).
 - Time above 217°C: 40 to 90s (depends on board type, thermal mass of the board/quantities in the reflow).
 - Ramp down: 5 to 6 C/s.
 - Using an inert reflow environment (with O₂ level about 5 to 15 ppm).

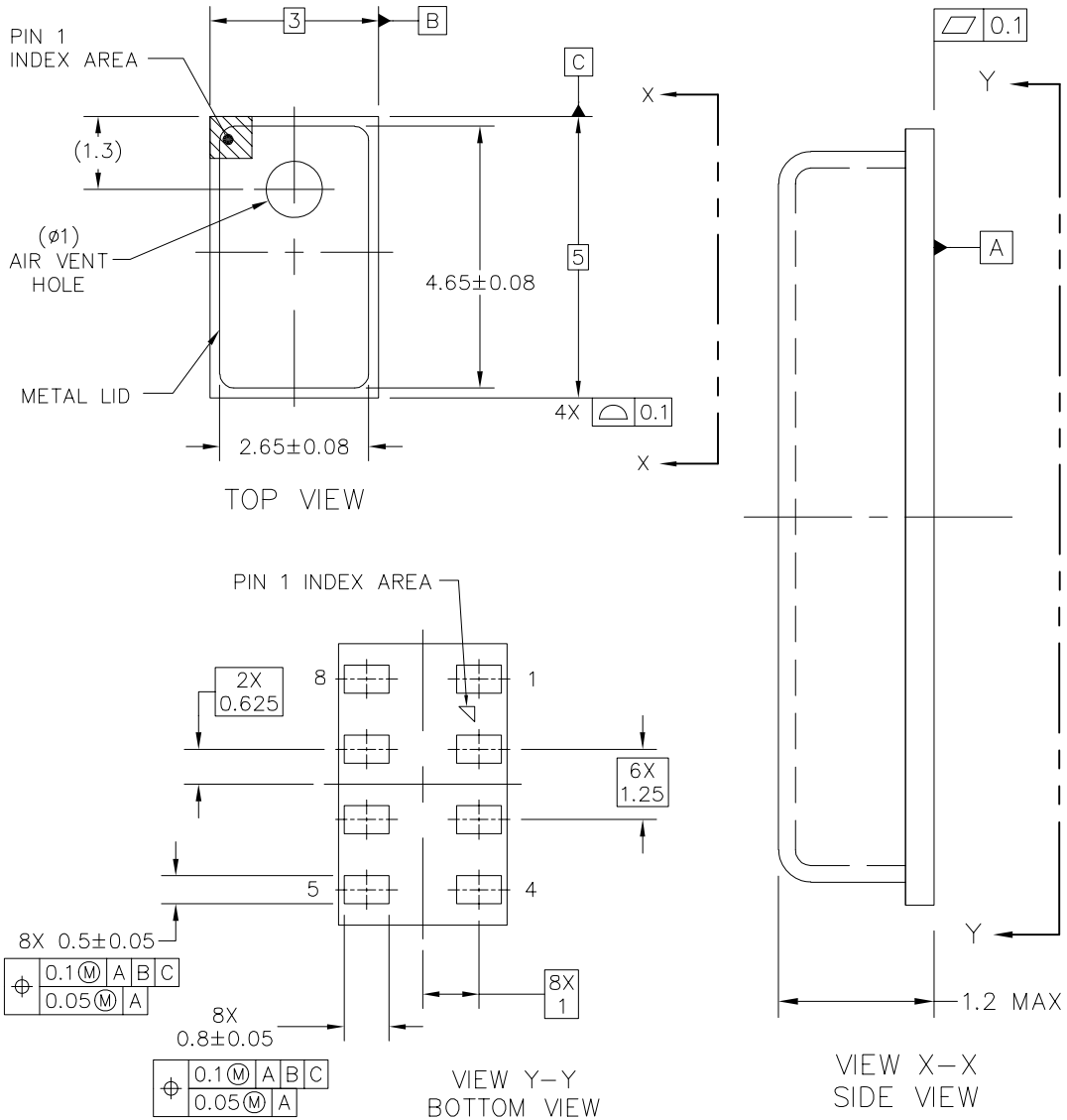
NOTE: The stress level and signal offset of the device also depends on the board type, board core material, board thickness and metal finishing of the board.

Handling Recommendations

It is recommended to handle the MPL115A Pressure Sensor with a vacuum pick and place tool. Sharp objects utilized to move the MPL115A Pressure Sensor increase the possibility of damage via a foreign object/tool into the small exposed port.

The sensor die is sensitive to light exposure. Direct light exposure through the port hole can lead to varied accuracy of pressure measurement. Avoid such exposure to the port during normal operation.

PACKAGE DIMENSIONS



| | | | |
|--|---------------------------|----------------------------|--|
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| | CASE NUMBER: 2015-02 | 15 APR 2009 | |
| | STANDARD: NON-JEDEC | | |

**CASE 2015-02
ISSUE 0
LGA PACKAGE**

PACKAGE DIMENSIONS

NOTES:

1. ALL DIMENSIONS IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
3. STYLE:

| | |
|-------------|-------------|
| PIN 1: VDD | PIN 5: CS |
| PIN 2: CAP | PIN 6: DOUT |
| PIN 3: GND | PIN 7: DIN |
| PIN 4: SHDN | PIN 8: SCLK |

| | | |
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MPL115A2

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