

# Freescale Semiconductor

MPL015A2  
Rev 0, 8/2010

## Miniature I<sup>2</sup>C Digital Barometer

The MPL015A2 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  $\mu$ A during Active mode and 0.06  $\mu$ 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.

MPL015A2 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 I<sup>2</sup>C port. Calibration Data is stored in internal ROM. Utilizing raw sensor output, the host microcontroller executes a compensation algorithm to render *Compensated Absolute Pressure*.

The MPL015A2 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
- I<sup>2</sup>C Interface
- Monotonic Pressure and Temperature Data Outputs
- Surface Mount RoHS Compliant Package

## MPL015A2

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

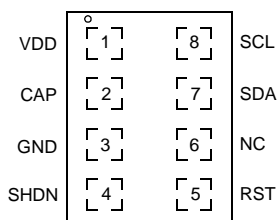
### ORDERING INFORMATION

Device Name	Package Options	Case No.	# of Ports			Pressure Type			Digital Interface
			None	Single	Dual	Gauge	Differential	Absolute	
MPL015A2T1	Tape & Reel	2015	•					•	I <sup>2</sup> C

### LGA PACKAGE



**MPL015A2**  
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 <sup>2</sup> C communications.
6	NC	NC: No connection.
7	SDA <sup>(1)</sup>	SDA: Serial data I/O line.
8	SCL <sup>(1)</sup>	I <sup>2</sup> C Serial Clock Input.

1. Use 4.7k pull-up resistors for I<sup>2</sup>C communication.

# Pressure

## 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,  $T_A = -40^\circ\text{C}$  to  $+105^\circ\text{C}$ , 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) @ 25°C	—	0.06	1	$\mu\text{A}$
			Standby	—	3.5	10	$\mu\text{A}$
			Average – at one measurement per second	—	5	6	$\mu\text{A}$
<b>Pressure Sensor</b>							
3	Range			50	—	115	kPa
4	Resolution			—	0.15	—	kPa
5	Accuracy		-20°C to 85°C	—	$\pm 1$	—	kPa
6	Accuracy Change over Temperature			—	$\pm 0.125$	—	kPa/°C
7	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
8	Conversion Time ( <i>Start Pressure Convert</i> )	$t_{cp}$	Time between start convert command and data available in the Pressure register	—	0.6	0.7	ms
<b>Temperature Sensor</b>							
9	Range			-40	—	105	°C
10	Conversion Time ( <i>Start Temperature Convert</i> )	$t_{ct}$	Time between start convert command and data available in the Temperature register	—	0.6	0.7	ms
11	Conversion Time ( <i>Start Both Convert</i> )	$t_{cb}$	Time between start convert command and data available in the Pressure and Temperature registers	—	0.8	1	ms
12	Resolution		Temperature ADC is 472 counts @ 25°C	—	-5.35	—	counts/°C
<b>I<sup>2</sup>C I/O Stages: SCL, SDA</b>							
13	SCL Clock Frequency	$f_{SCL}$		—	—	400	KHz
14	Low Level Input Voltage	$V_{IL}$		—	—	$0.3V_{DD}$	V
15	High Level Input Voltage	$V_{IH}$		$0.7V_{DD}$	—	—	V
<b>I<sup>2</sup>C Outputs: SDA</b>							
16	Data Setup Time	$t_{SU}$	Setup time from command receipt to ready to transmit	100	—	—	ns
<b>I<sup>2</sup>C Addressing</b>							
MPL015A2 uses 7-bit addressing, does not acknowledge the general call address 0000000. Slave address has been set to 0x60 or 1100000.							

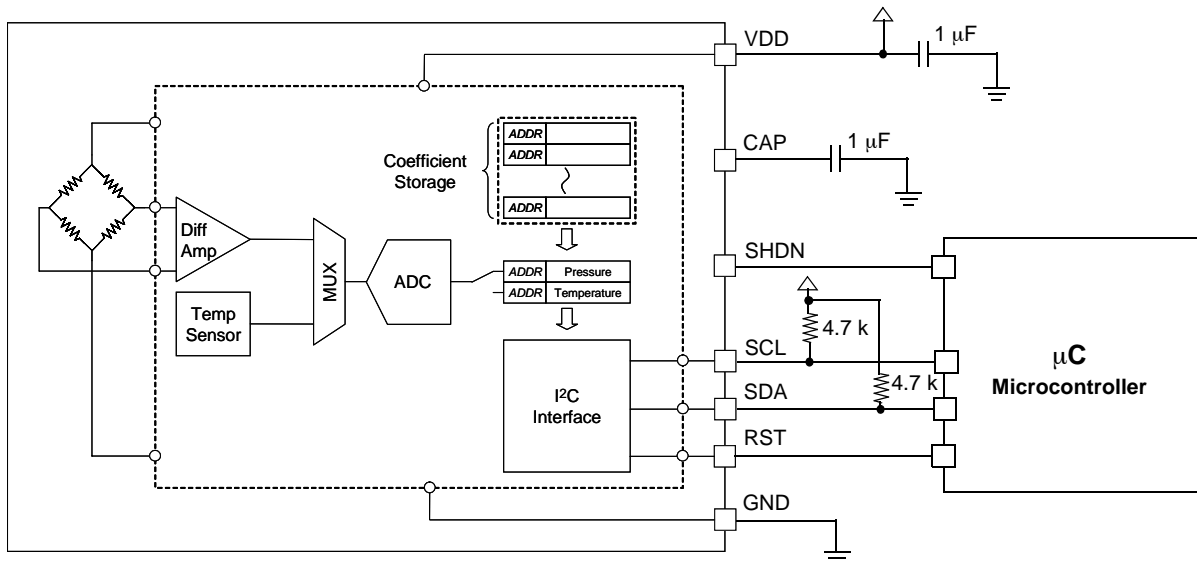


Figure 1. Block Diagram

## Compensation

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

$$P_{comp} = a_0 + (b_1 + P_{adc} + c_{12} * T_{adc}) * P_{adc} + (b_2 + T_{adc}) * T_{adc}$$

Where:

- $P_{adc}$  is the 10-bit pressure output of the MPL015A2 ADC,
- $T_{adc}$  is the 10-bit temperature output of the MPL015A2 ADC,
- $a_0$  is the pressure offset coefficient,
- $b_1$  is the pressure sensitivity coefficient,
- $c_{12}$  is the coefficient for temperature sensitivity coefficient (TCS),
- $b_2$  is the 1st order temperature offset coefficient (TCO),

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.

## Pressure

### 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	
Total Bits	16	16	16	14	62
Sign Bits	1	1	1	1	
Integer Bits	12	2	1	0	
Fractional Bits	4	13	14	13	
dec pt zero pad	—	—	—	9	

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

Example Binary Format Definitions:

- Sign = 0, Integer Bits = 8, Fractional Bits = 4 :                      Coeff = S I<sub>7</sub> I<sub>6</sub> I<sub>5</sub> I<sub>4</sub> I<sub>3</sub> I<sub>2</sub> I<sub>1</sub> I<sub>0</sub> . F<sub>3</sub> F<sub>2</sub> F<sub>1</sub> F<sub>0</sub>
- Sign = 1, Integer Bits = 4, Fractional Bits = 7 :                      Coeff = S I<sub>3</sub> I<sub>2</sub> I<sub>1</sub> I<sub>0</sub> . F<sub>6</sub> F<sub>5</sub> F<sub>4</sub> F<sub>3</sub> F<sub>2</sub> F<sub>1</sub> F<sub>0</sub>
- Sign = 0, Integer Bits = 0, Fractional Bits = 6, dec pt zero pad = 2 :      Coeff = S 0 . 0 0 F<sub>5</sub> F<sub>4</sub> F<sub>3</sub> F<sub>2</sub> F<sub>1</sub> F<sub>0</sub>
- Sign = 0, Integer Bits = 0, Fractional Bits = 5, dec pt zero pad = 3 :      Coeff = S 0 . 0 0 0 F<sub>4</sub> F<sub>3</sub> F<sub>2</sub> F<sub>1</sub> F<sub>0</sub>

**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

For coefficients with less than 16 bits, the lower LSBs are zero. For example, c14 is 14 bits and is stored into 2 bytes as follows:

$$c14 \text{ MS byte} = c14[10:3] = [c14_{b13}, c14_{b12}, c14_{b11}, c14_{b10}, c14_{b9}, c14_{b8}, c14_{b7}, c14_{b6}]$$

$$c14 \text{ LS byte} = c14[2:0] \& \text{"00000"} = [c14_{b5}, c14_{b4}, c14_{b3}, c14_{b2}, c14_{b1}, c14_{b0}, 0, 0]$$

## 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 O<sub>2</sub> level about 5 to 15 ppm).

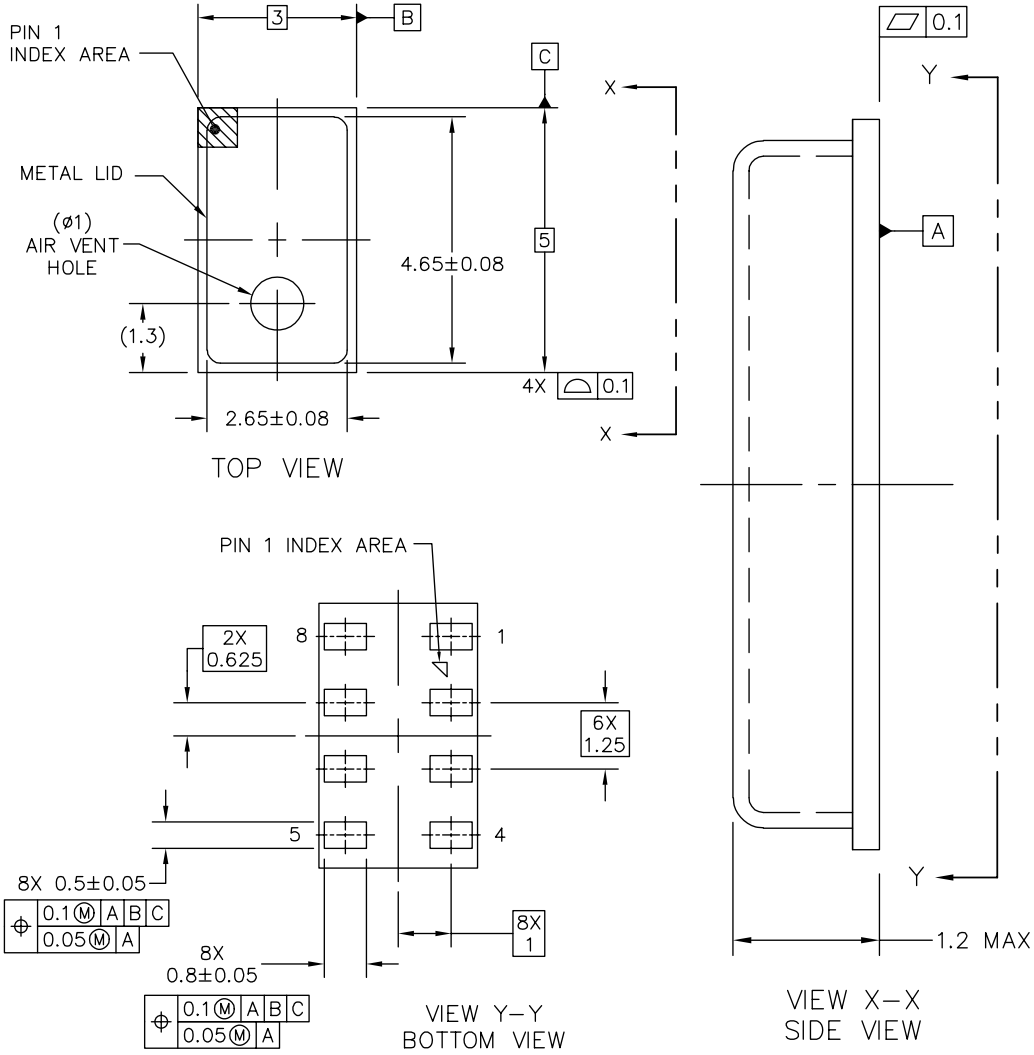
**NOTE:** The stress level and signal offset of the device also depends on the board type, board core material, board thickness and metal finishing of the board.

## Handling Recommendations

It is recommended to handle the MPL015A pressure sensor with a vacuum pick and place tool. Sharp objects utilized to move the MPL015A 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	10 MAR 2010
	STANDARD: NON-JEDEC	

**CASE 2015-02  
ISSUE A  
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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MPL015A2

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