Freescale Semiconductor

MPL115A1
Rev 4, 03/2010

Miniature SPI Digital Barometer

MPL115A1
50 to 115 kPa

The MPL115A1 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 µA during Active mode and 1 µA 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.

MPL115A1 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 a SPI 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 MPL115A1 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
- SPI Interface
- Monotonic Pressure and Temperature Data Outputs
- Surface Mount RoHS Compliant Package

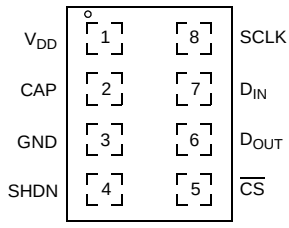
Application Examples

- 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	
MPL115A1T1	Tape & Reel	2015	•					•	SPI

LGA PACKAGE

MPL115A1
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. When in shut down the part draws < 1µA supply current
5	$\overline{CS}$	$\overline{CS}$: SPI Chip Select line.
6	DOUT	DOUT: Serial data output.
7	DIN	DIN: Serial data input.
8	SCLK	SPI Serial Clock Input.

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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_{DD} = 3.3 V, T_A = +25°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	—	µA
Pressure Sensor							
3	Range			50	—	115	kPa
4	Resolution			—	0.15	—	kPa
5	Accuracy		-20ºC to 85ºC	—	±1	—	kPa
6	Conversion Time (*Start Pressure Convert*)	tcp	Time between start convert command and data available in the Pressure register	—	0.6	0.7	ms
Temperature Sensor							
7	Range			-40	—	105	ºC
8	Conversion Time *(Start Temperature Convert*)	tct	Time between start convert command and data available in the Temperature register	—	0.6	0.7	ms
9	Conversion Time *(Start Both Convert*)	tcb	Time between start convert command and data available in the Pressure and Temperature registers	—	0.8	1	ms
10	Resolution		Temperature ADC is 472 counts at 25ºC	—	-5.35	—	counts/ºC
SPI Inputs: SCLK, $\overline{CS}$, D_{IN}							
11	SCLK Clock Frequency	f_{SCLK}	(1)	—	—	8	MHz
12	Low Level Input Voltage	VIL		—	—	$0.3V_{DD}$	V
13	High Level Input Voltage	VIH		$0.7V_{DD}$	—	—	V
SPI Outputs: D_{OUT}							
14	Low Level Output Voltage	VOL1	At 3 mA sink current	0	—	0.4	V
		VOL2	At 6 mA sink current	0	—	0.6	
15	High Level Output Voltage	VOH1	At 3 mA source current	V_{DD} – 0.4 V	—	—	V

1. Nominal maximum SPI clock frequency.

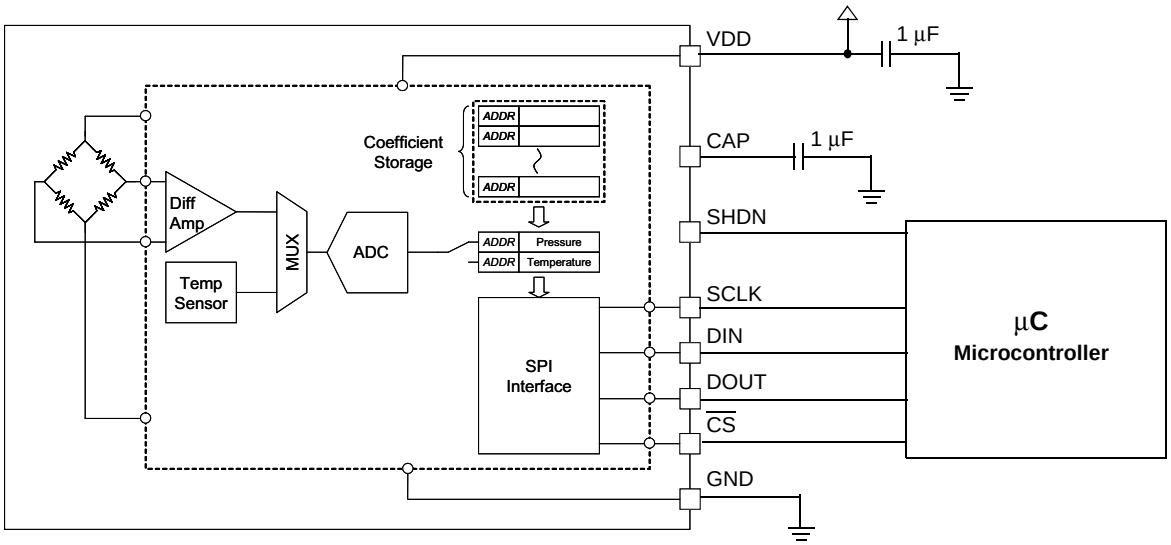

Figure 1. Uncompensated Pressure Sensor Schematic

Compensation

The pressure compensation for MPL115A1 is based on a 2-dimensional, second order polynomial based on Microsystems mst_trimlib library.

The 10-bit compensated pressure output, Pcomp, is calculated as follows:

$$Pcomp = a0 + (b1 + c11*Padc + c12*Tadc) * Padc + (b2 + c22*Tadc) * Tadc$$

Where:

Padc is the 10-bit pressure output of the MPL115A1 ADC,

Tadc is the 10-bit temperature output of the MPL115A1 ADC,

a0 is the pressure offset coefficient,

b1 is the pressure sensitivity coefficient,

c11 is the pressure linearity (2nd order) coefficient,

c12 is the coefficient for temperature sensitivity coefficient (TCS),

b2 is the 1st order temperature offset coefficient (TCO),

c22 is the 2nd order temperature offset coefficient.

Ideally, Pcomp 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	3	13	14	13	11	10	
dec pt zero pad	—	—	—	9	11	15	

Example Binary Format Definitions:

1. 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
2. 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
3. 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
4. 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 MS byte = c11[10:3] = [$c11_{b10}$, $c11_{b9}$, $c11_{b8}$, $c11_{b7}$, $c11_{b6}$, $c11_{b5}$, $c11_{b4}$, $c11_{b3}$]

NOTE: c11 LS byte = c11[2:0] & "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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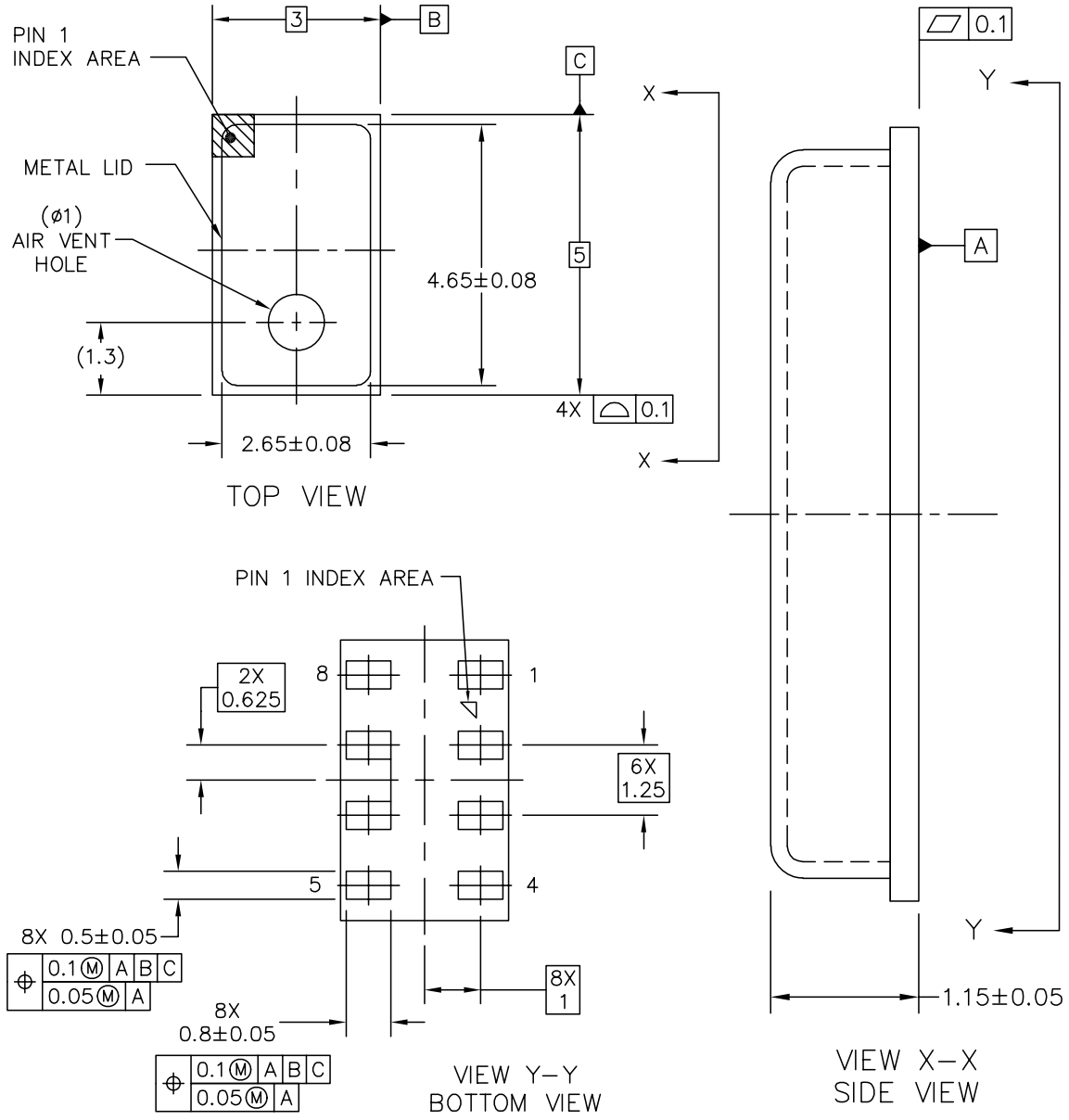

TITLE: LGA 8 I/O, 3 X 5 X 1.25 PITCH SENSOR 1.15 PKG	CASE NUMBER: 2015–01	
	STANDARD: NON–JEDEC	
	PACKAGE CODE: TBD	SHEET: 1 OF 3

CASE 2015-02
ISSUE O
LGA PACKAGE

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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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		STANDARD: NON–JEDEC	
		PACKAGE CODE: TBD	SHEET: 2

CASE 2015-02
ISSUE O
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Web Support:
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USA/Europe or Locations Not Listed:
Freescale Semiconductor, Inc.
Technical Information Center, EL516
2100 East Elliot Road
Tempe, Arizona 85284
1-800-521-6274 or +1-480-768-2130
www.freescale.com/support

Europe, Middle East, and Africa:
Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
www.freescale.com/support

Japan:
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:
Freescale Semiconductor China Ltd.
Exchange Building 23F
No. 118 Jianguo Road
Chaoyang District
Beijing 100022
China
+86 010 5879 8000
support.asia@freescale.com

For Literature Requests Only:
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