



Consensic

CPS121

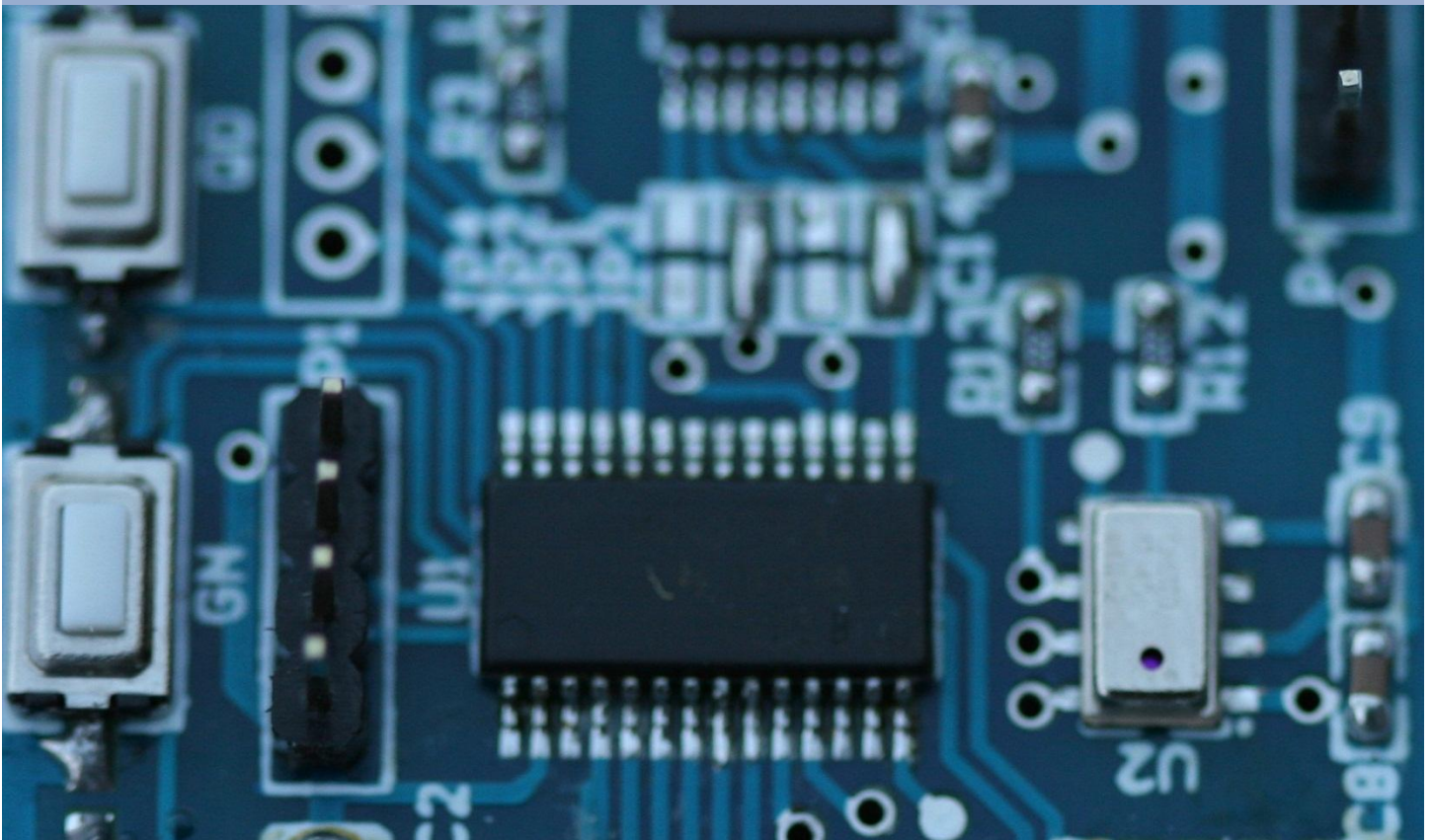
Data Sheet

Digital Barometer

Rev 4.0

January 2016

DAT-0007



CPS121

Digital Barometer



Overview

The CPS121 system-in-a-package (SIP) solution comprises of a resistive bridge type pressure sensor and a 24-bit ADC for high resolution and accurate pressure measurements. The fully calibrated pressure and temperature compensated digital output makes the CPS121 solution simple to use. The CPS121 includes internal calibration logic that provides accurate pressure and temperature measurements to the application via the SPI or I²C interface. There is no need to separately download internal calibration coefficients and have the host microcontroller perform complicated compensation calculations.

Applications

- Smartphones
- Wearables
- Altimeters
- Portable and Stationary Barometers
- Weather Stations
- GPS Applications
- Hard Disk Drives (HDD)
- Industrial Equipment
- Air Control Systems
- Vacuum Systems

Benefits

- Low Power Consumption
- Excellent for Battery Applications
- External Clock not Required
- High Resistance to Sensing Media

Features

- Factory Calibrated Pressure and Temperature Sensor
- Supply Voltage: 2V to 5.5V (3V @typical)
- Average Current Consumption: <5uA (One Measurement)
- Sleep State Current Consumption: <200nA (25°C)
- Operating Temperature Range: -40°C to +85°C
- Pressure Absolute Accuracy: ±0.1kPa (±1.0mbar) @ 0°C to 50°C, 95kPa to 105kPa
- Pressure Relative Accuracy: ±0.01kPa (<1m)
- Temperature Accuracy: ±1.0°C

Interfaces

- I²C (up to 400kHz)
- SPI (Half-Duplex, 3-Wire)

Physical Characteristics

- Small Form Factor, 3 x 5 x 1.2mm (w x l x h)
- LGA Package, 8 Lead
- Top Side Sensing Port



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CPS121 BLOCK DIAGRAM

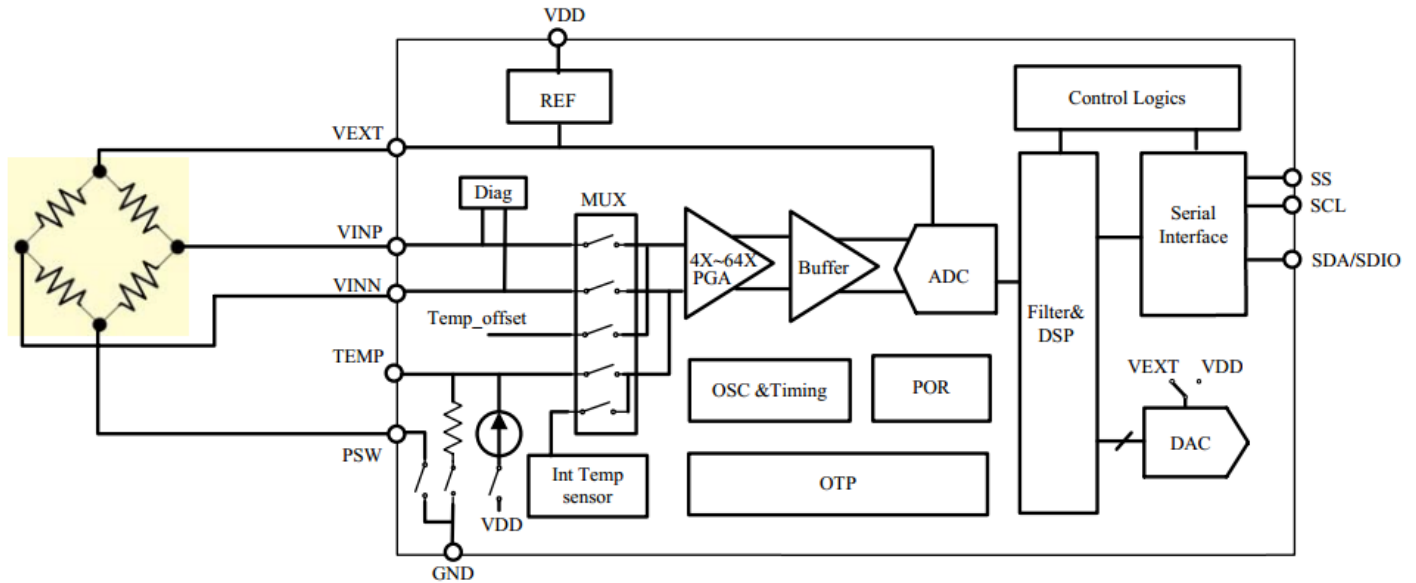


TABLE 1: ORDERING INFORMATION

PART NUMBER	OUTPUT MODE	OPERATION MODE	PACKAGE
CPS121	I ² C / SPI (Half-Duplex)	Sleep	8-Lead LGA

SALES and CONTACT INFORMATION

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1 OPERATING CHARACTERISTICS

1.1 ABSOLUTE RATINGS

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Over Pressure					2X FS	kPa (bar)
Supply Voltage (with respect to GND)	V_{DD}		-0.3		6.5	V
Voltages at Analog and Digital I/O Pins	V_{A_IO} V_{D_IO}		-0.3		$V_{DD} + 0.3$	V
Storage Temperature	T_{STOR}		-60		150	°C

1.2 OPERATING CONDITIONS

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
PRESSURE SENSOR						
Range			30 (300)		120 (1200)	kPa (mbar)
Resolution ¹				0.17		Pa
Noise in Pressure		Full Bandwidth, Normal Mode Altitude Based on Relative Pressure		1 10		Pa cm
Accuracy		30 to 120kPa (-20°C to 0°C)	-0.2 (-2.0)	±0.17 (±1.7)	+0.2 (+2.0)	kPa (mbar)
		30 to 120kPa (0°C to 65°C)	-0.15 (-1.5)	±0.10 (±1.0)	+0.12 (+1.2)	kPa (mbar)
Solder Drifts			-0.1		+0.2	kPa
TEMPERATURE SENSOR						
Range			-40		85	°C
Resolution				0.003		°C
Accuracy		-40°C to 85°C	-1	±0.75	+1	°C
OPERATION						
Supply Voltage to GND ²	V_{SUPPLY}		2	3.0	5.5	V
Operating Temperature Range			-40		85	°C
I ² C Pull-Up Resistors	R_{PU}		1	2.2		kΩ

¹ Guaranteed by design of 24bits ADC, and calculated according to the range in application.

² Factory calibrated for Pressure and Temperature at 3.0V±10%. Output accuracy will be affected if used outside this range. Other ranges available upon request.

1.3 ELECTRICAL PARAMETERS

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SUPPLY CURRENT						
Supply Current, average ¹ during conversion ² standby (no conversion)	I _{avg} I _{SC} I _{SS}	VDD = 3V		3.95 1.5	0.2	μA mA μA
ANALOG TO DIGITAL CONVERTER						
Resolution	r _{ADC}				24	Bit
I ² C Clock Frequency	F _{C,I2C}				400	kHz
SPI Clock Frequency	F _{C,SPI}				10	MHz
¹ Under the assumption of one conversion every second. Conversion means either a pressure or a temperature measurement ² During conversion, the sensor will be switched on to VDD, and after conversion ended, the sensor will automatically be switched off from VDD.						

2 OPERATION MODES

The CPS121 is factory programmed to Sleep Mode. In this mode, the CPS121 remains asleep until the master/host sends a measurement request (MR) before taking sensor measurements. After the CPS121 receives an MR command, it wakes up, runs a full measurement cycle, stores the measurement data in internal registers and then returns to sleep mode again.

3 OUTPUT MODES

3.1 I²C AND SPI

Two-wire I²C and three-wire (half-duplex) SPI are available for reading sensor measurement data from the CPS121. The interface is selectable by setting the digital voltage level on the SS pin:

- SS = 0 → SPI Mode
- SS = 1 or float → I²C Mode

When SS = 0, SPI mode is selected. When SS = 1 or not connected (internal pull-up at SS pin), I²C mode is selected.

The factory setting for the I²C slave address is 0x6C and the communication is restricted to this address only.

- I²C Address = 0x6C

3.2 I²C AND SPI COMMANDS

Table 2 details the commands to interface with the device in the I²C and SPI modes.

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TABLE 2: I²C AND SPI COMMANDS

TYPE	DESCRIPTION	SUPPORT
Measurement Request (MR)	Wakes up the CPS121, performs a sensor measurement, stores the sensor measurement data in internal registers and returns to sleep	I ² C and SPI
Get Data (GD)	Retrieves the sensor measurement data from the internal CPS121 registers*.	I ² C and SPI

**Note: GD does not initiate a new measurement. Repeated GD commands will return the same (or stale) sensor measurement data. An MR is required to perform a full sensor measurement cycle to refresh the sensor register data.*

The Get Data (GD) command is used to read out data from the CPS121. With the start of communication (for I²C after reading the slave address; for SPI at the falling-edge of SS) the entire sensor measurement output packet will be loaded in a serial output register. The register will be updated after the communication is finished. The output is always scaled to 24-bits.

The ordering of the bits is “big-endian”.

3.3 I²C GET DATA (GD)

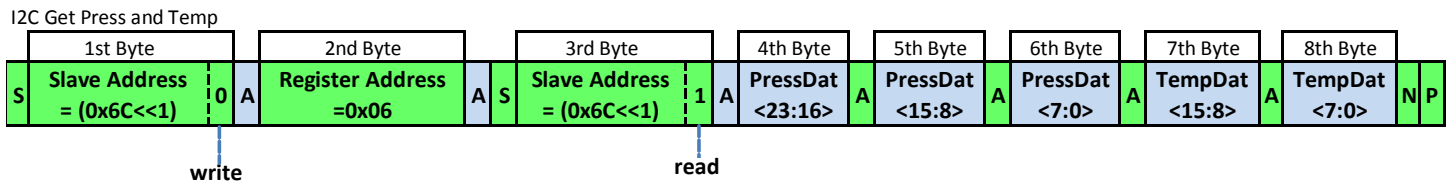
An I²C Get Data command starts with the 7-bit slave address and the 8th bit = 1 (READ). The device then sends acknowledge (ACK), indicating I²C communication success. The number of data bytes returned by the device is determined by the master, which controls NACK and stop conditions.

Figure 1 displays an example for sending three bytes followed by reading five bytes. The first byte contains the I²C address followed by internal register address (0x06). Then the I²C address is repeated, followed by the slave sending out three pressure bytes and two temperature bytes.

The GD command is used to retrieve the pressure and temperature sensor data after an MR command has been executed.

Note that the two temperature byte codes are formatted in 2's complement.

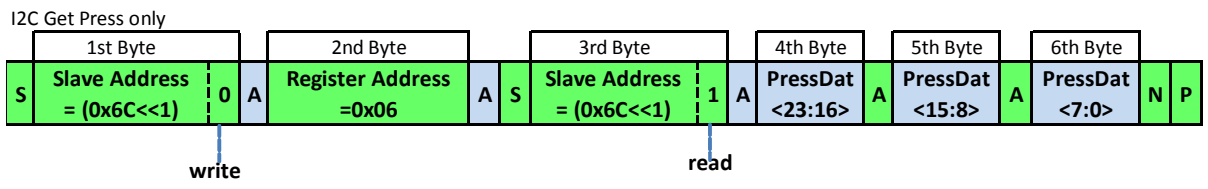
FIGURE 1: SLAVE ADDRESS FOLLOWED BY THREE PRESSURE AND TWO TEMPERATURE BYTES



- from master to slave
- from slave to master
- S START condition
- P STOP condition
- A Acknowledge
- N Not Acknowledge

For Pressure data only, the data stream can be terminated after the sixth pressure byte. See Figure 2 below.

FIGURE 2: 7-BIT SLAVE ADDRESS FOLLOWED BY THREE PRESSURE BYTES



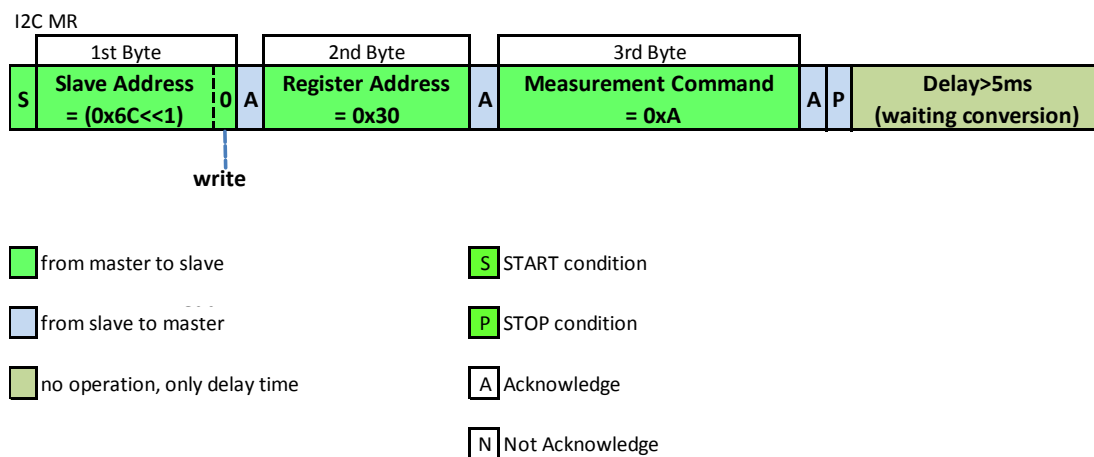
- from master to slave
- from slave to master
- S START condition
- P STOP condition
- A Acknowledge
- N Not Acknowledge

3.4 I²C MEASUREMENT REQUEST (MR)

The I²C MR is used to wake up the device from Sleep Mode and start a complete sensor measurement cycle, before the device returns to Sleep Mode again. The measurement cycles starts with a pressure measurement followed by a temperature measurement. The sensor measurements are digitized and run through an onboard compensation algorithm before the final measurement values are written to the digital output register. As shown in Figure 3, the communication requires the slave address (0x6C) and a WRITE bit (0) to initiate the MR. This is followed by two bytes; register address (0x30) and measurement (0xA). After the CPS121 responds with the slave ACK, the master terminates the communication with a stop condition.

Sensor measurement conversion time takes approximately 5ms, so MRs should not be sent faster than every 5ms.

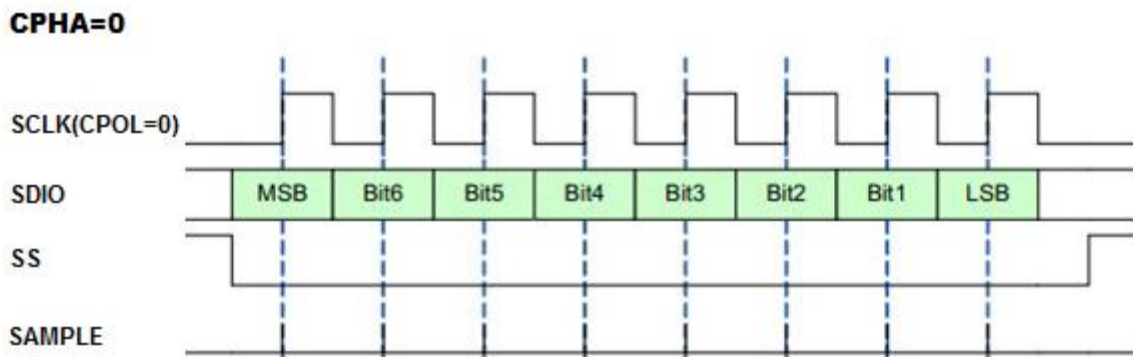
FIGURE 3: I²C MEASUREMENT REQUEST COMMAND



3.5 SPI GET DATA (GD)

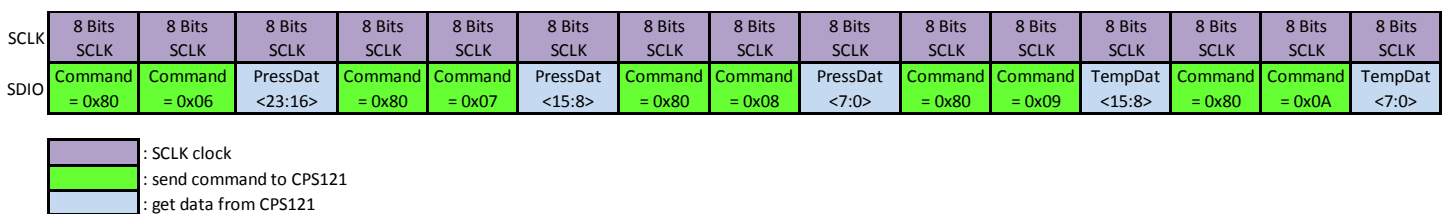
The SPI Mode is available when the SS pin =0. The default is set for Data latch on rising edge and data output on the falling edge of SCLK.

FIGURE 4: DEFAULT SPI INTERFACE MODE



In Figure 5, the entire output packet is 15 bytes. Command byte value 0x80 means read sensor values, whereas 0x06 and 0x0A refer to the addresses where the pressure and temperature values are stored, respectively. If the user only requires a pressure measurement, the read can be terminated after the ninth byte for pressure only measurements.

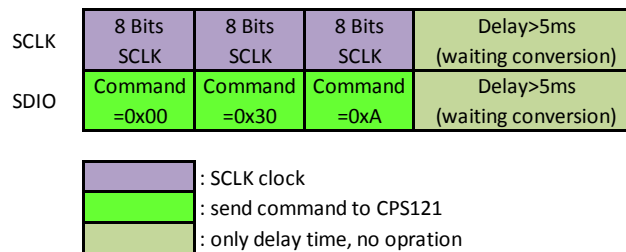
FIGURE 5: SPI GET DATA AFTER MEASUREMENT REQUEST



3.6 SPI MEASUREMENT REQUEST (MR)

The SPI MR is used to wake up the device in Sleep mode and start a complete pressure measurement and temperature measurement cycle. The SPI MR command consists of three bytes, 0x00, 0x03 and 0x0A.

FIGURE 6: SPI MEASUREMENT REQUEST COMMAND



4 CALCULATING OUTPUT

After retrieving the data, the compensated output can be scaled to real world values by following the equations below.

4.1 PRESSURE OUTPUT

An example of the 24-bit compensated pressure with a full scale range of 30 to 120kPa can be calculated as follows:

$$\text{Pressure [kPa]} = (\text{Pressure 3rd Byte [23:16]} \times 65536 + \text{Pressure 2nd Byte [15:8]} \times 256 + \text{Pressure 1st Byte [7:0]}) / 2^6 / 1000$$

4.2 TEMPERATURE OUTPUT

The 16-bit compensated temperature can be calculated as follows:

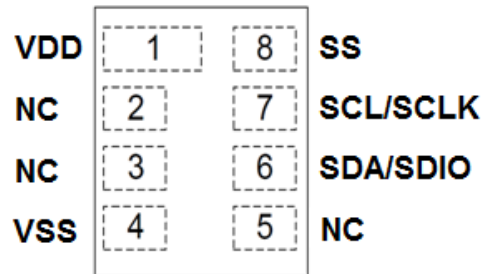
$$\text{Positive Temperature [}^\circ\text{C]} = (\text{Temperature High Byte [15:8]} \times 256 + \text{Temperature Low Byte [7:0]}) / 2^8$$

$$\text{Negative Temperature [}^\circ\text{C]} = (\text{Temperature High Byte [15:8]} \times 256 + \text{Temperature Low Byte [7:0]} - 65536) / 2^8$$

5 PACKAGE AND ASSEMBLY

The CPS121 is available in an 8-pin LGA package.

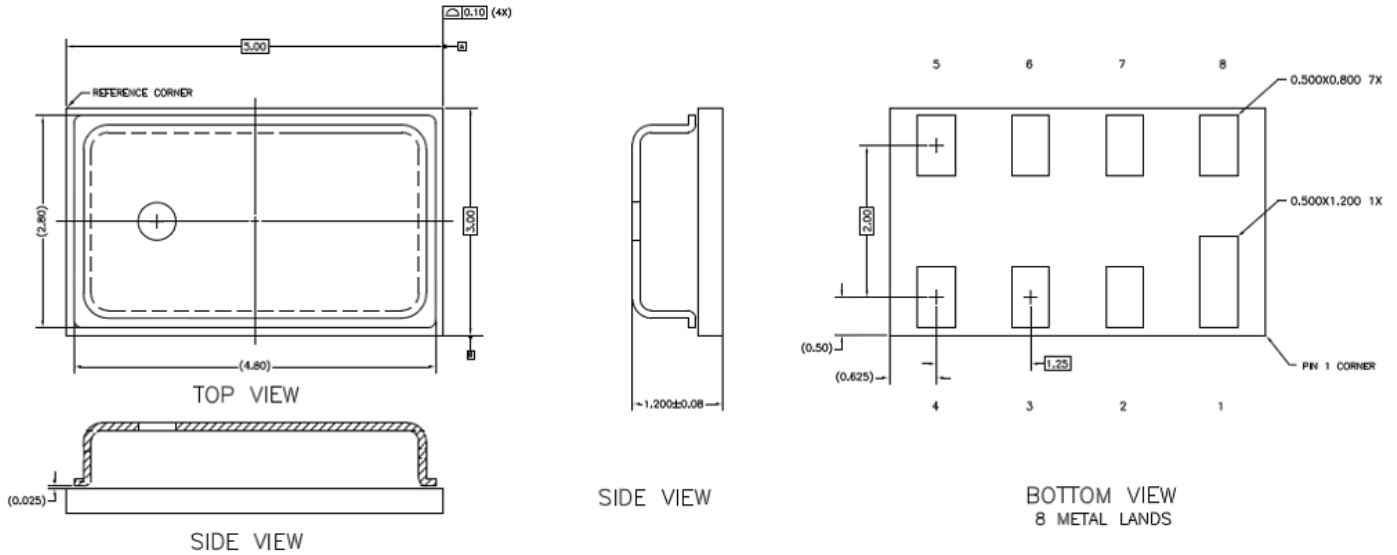
5.1 PIN ASSEMBLY AND MECHANICAL DRAWING



Pin	Name	Function
1	VDD	Power Supply, Connect 0.1uF CAP to GND
2	NC	Not Connect
3	NC	Not Connect
4	VSS	Ground
5	NC	Not Connect
6	SDA/SDIO	I2C Data and SPI data In/Out
7	SCL/SCLK	I2C and SPI Clock
8	SS	=1 or float I2C is selected, =0 SPI is selected

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DIMENSION	MIN.	TYP.	MAX.	UNITS
Length		5		mm
Width		3		mm
Height		1.2		mm
Pad 1 Length		0.5		mm
Pad 1 Width		1.2		mm
Pad 2 to 8 Length		0.5		mm
Pad 2 to 8 Width		0.8		mm
Pad Pitch (Y-Axis)		2.0		mm
Pad Pitch (X-Axis)		1.25		mm
Port Hole Diameter		0.5		mm

5.2 SOLDERING CONDITIONS

TABLE4: PACKAGE REFLOW TEMPERATURE

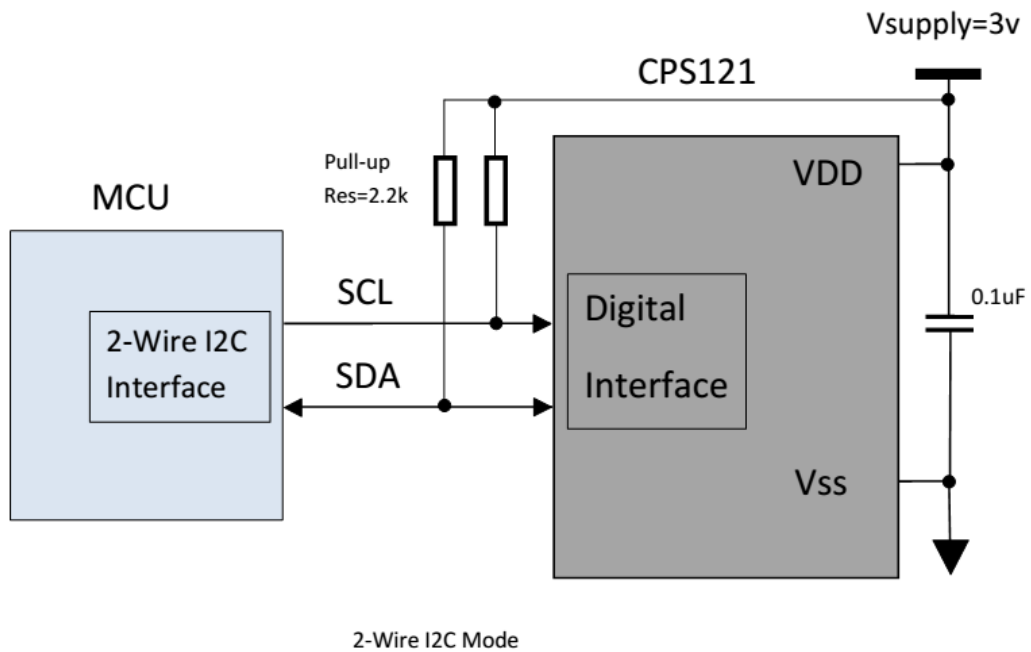
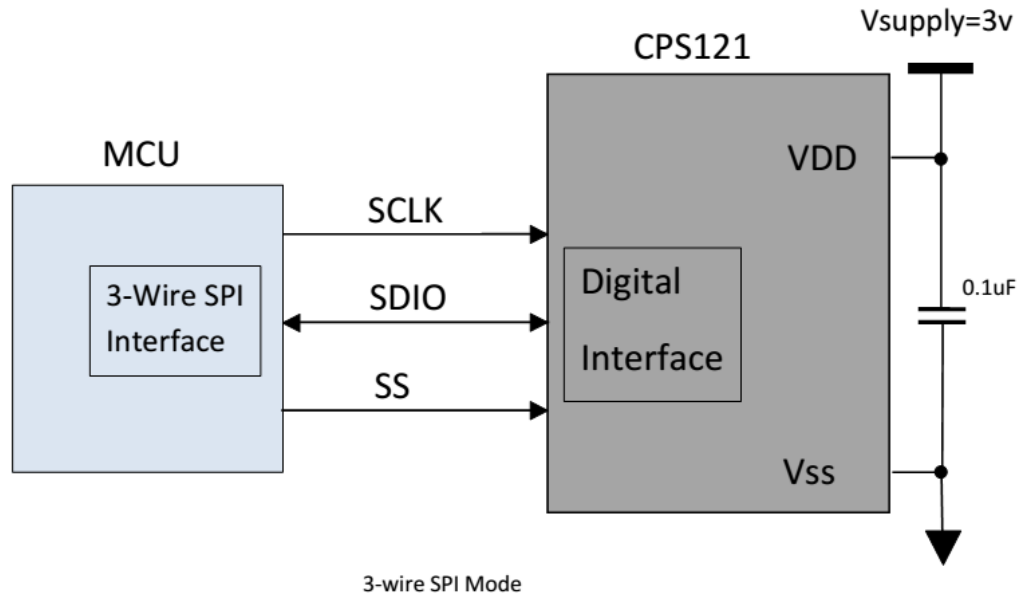
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Soldering Peak Temperature	Less than 30 seconds (JEDEC-STD-020 Standard)			260	°C

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6 APPLICATION DIAGRAM



7 DOCUMENT HISTORY

REVISION	DATE	DESCRIPTION
0.1	04-DEC-2013	Preliminary
1.0	11-Mar-2014	Modify Pressure Accuracy
1.1	08-APR-2014	Modify I2C command
2.0	21-APR-2014	Production Release
3.0	08-NOV-2015	Added Detailed Description of Power Consumption, Changed Part Number, Updated Negative Temperature Formula
4.0	26-JAN-2016	Clarified SPI 3-Wire Functionality, Added Application Diagrams, Expand Accuracy Spec

8 DISCLAIMER

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