CPS121

Data Sheet

Digital Barometer

CPS121
Digital Barometer

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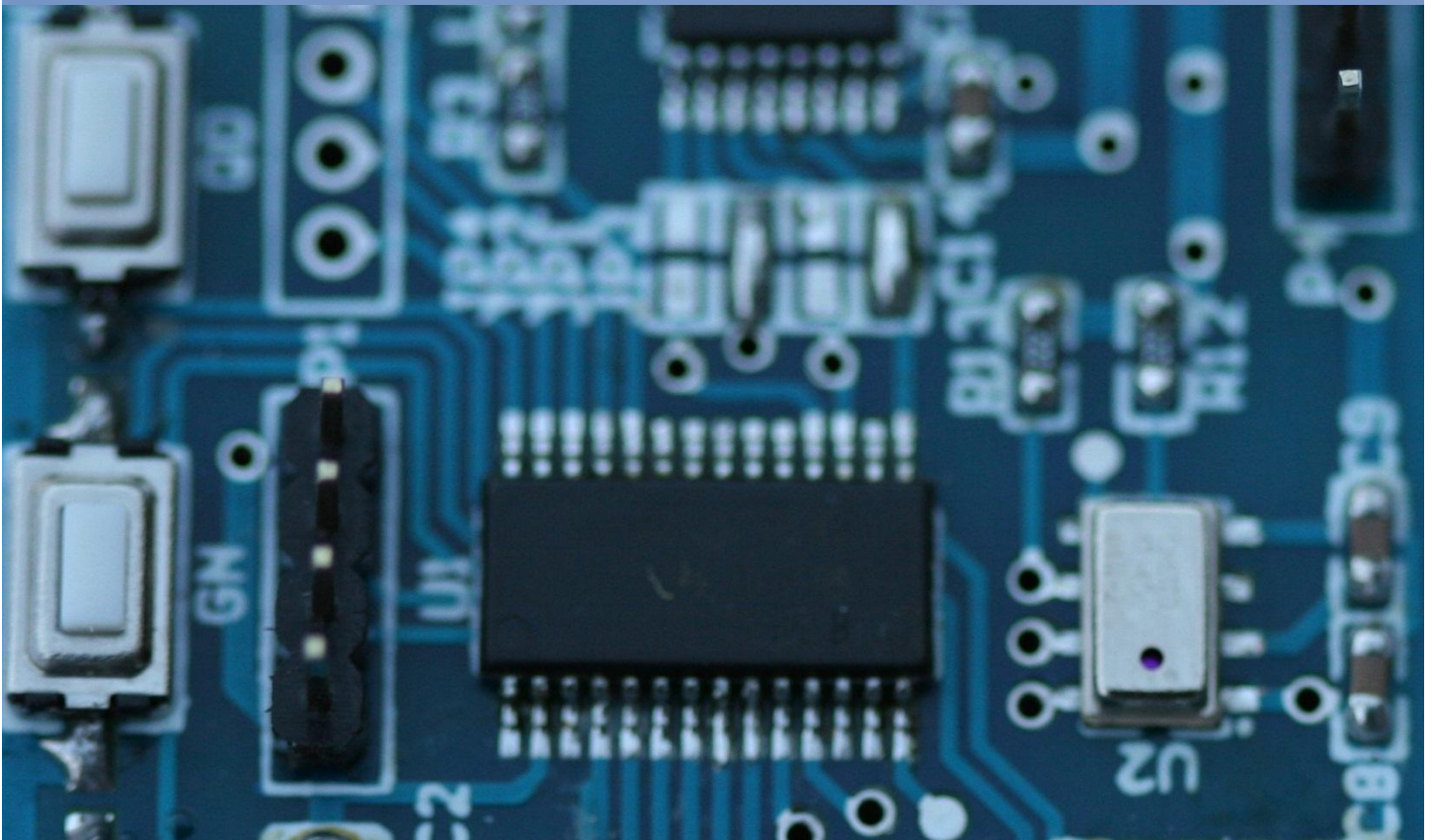
Overview

The CPS121 system-in-a-package (SIP) solution comprises of aresistive 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 CPS121includes 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°Cto 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)
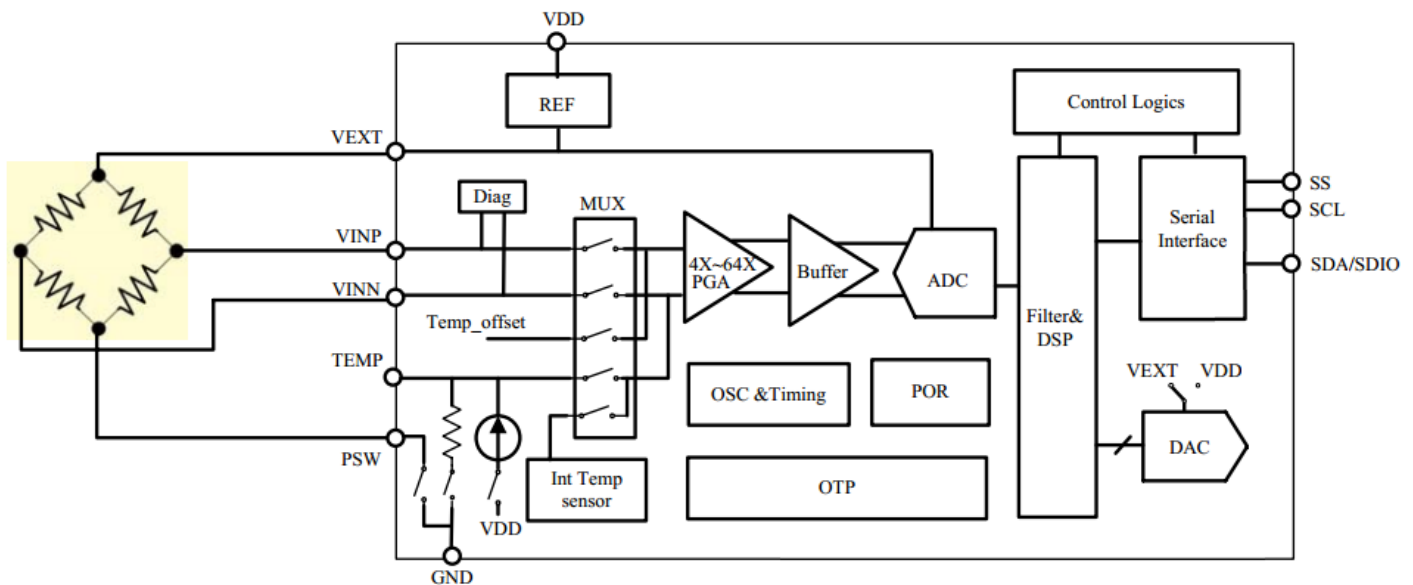- LGA Package, 8 Lead
- Top Side Sensing Port

RoHS Compliant

CPS121 BLOCK DIAGRAM

TABLE1:   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		1		Pa
		Altitude Based on Relative Pressure		10		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
I²C 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)	Iavg Isc Iss	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 CPS121remains asleep until the master/host sends a measurement request (MR) before taking sensor measurements. After the CPS121 receives anMR command, it wakes up, runs a full measurementcycle, stores the measurement data in internal registers and then returns to sleep mode again.

3   OUTPUT MODES

3.1 I^{2}C AND SPI

Two-wire I^{2}C 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→ I^{2}C Mode

When SS=0, SPI mode is selected. When SS=1 or not connected (internal pull-up at SS pin), I^{2}C mode is selected.

The factory setting for the I^{2}C slave address is 0x6C and the communication is restricted to this address only.

- I^{2}C Address = 0x6C

3.2 I^{2}C AND SPICOMMANDS

Table 2 details the commands to interface with the device in the I^{2}C and SPI modes.

TABLE 2: I^{2}C 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 I^{2}C 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".
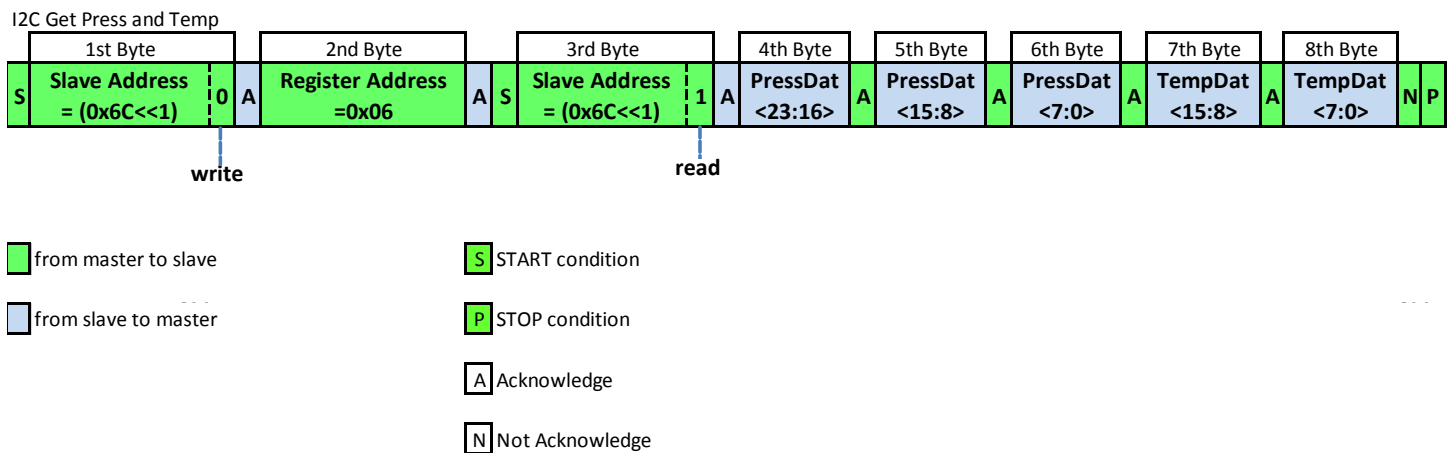
3.3 I^{2}C GET DATA (GD)

An I^{2}C Get Data command starts with the 7-bit slave address and the 8th bit = 1 (READ). The device then sends acknowledge (ACK), indicating I^{2}C 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 and example forsending three bytes followed by readingfive bytes. The first byte contains the I^{2}C address followed byinternal register address(0x06). Then theI^{2}C 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 anMR command has been executed.

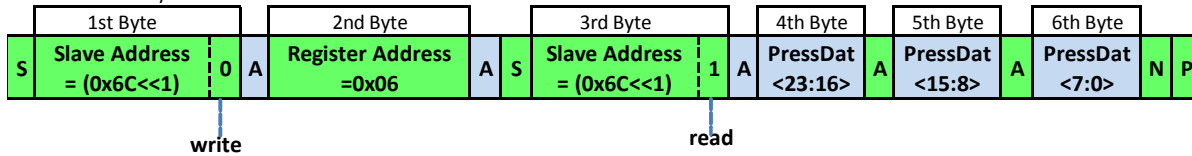Note that the two temperature byte codes are formatted in 2's complement.

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

I2C Get Press and Temp

1st Byte			2nd Byte			3rd Byte			4th Byte		5th Byte		6th Byte		7th Byte		8th Byte		
S	Slave Address = (0x6C<<1)	0 A	Register Address =0x06	A	S	Slave Address = (0x6C<<1)	1 A	PressDat <23:16>	A	PressDat <15:8>	A	PressDat <7:0>	A	TempDat <15:8>	A	TempDat <7:0>	N P

write   **read**

- (green) from master to slave
- (blue) 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

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I2C Get Press only

	1st Byte			2nd Byte			3rd Byte			4th Byte		5th Byte		6th Byte		
S	Slave Address = (0x6C<<1)	0	A	Register Address =0x06	A	S	Slave Address = (0x6C<<1)	1	A	PressDat <23:16>	A	PressDat <15:8>	A	PressDat <7:0>	N	P

write   read

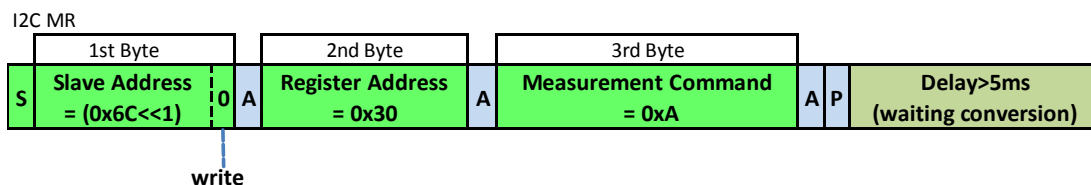|	
▮ from master to slave	S START condition
▮ from slave to master	P STOP condition
	A Acknowledge
	N Not Acknowledge

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 apressure 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

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I2C MR

	1st Byte			2nd Byte		3rd Byte			
S	Slave Address = (0x6C<<1)	0	A	Register Address = 0x30	A	Measurement Command = 0xA	A	P	Delay>5ms (waiting conversion)

write

- ▮ from master to slave
- ▯ from slave to master
- ▮ no operation, only delay time

- **S** START condition
- **P** STOP condition
- A Acknowledge
- N Not Acknowledge

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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
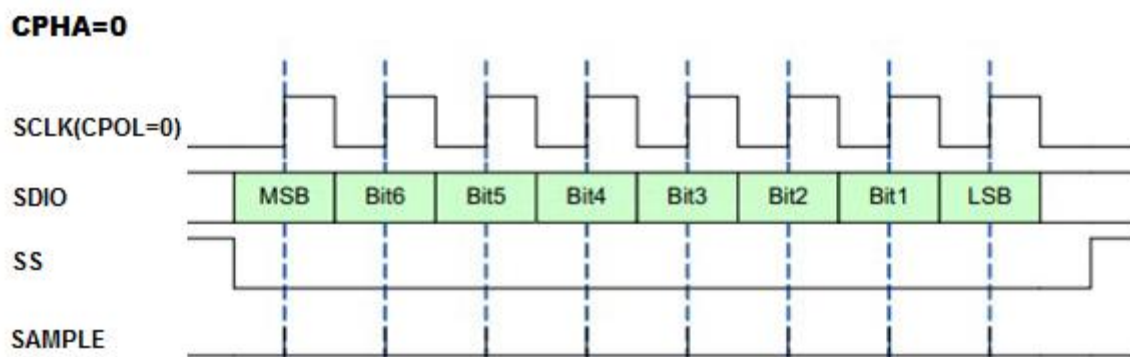
In Figure 5, the entire output packet is 15bytes. Command byte value 0x80 means read sensor values, whereas 0x06 and 0x0A refer to the addresses where the pressure and temperaturevalues are stored, respectively. If the user only requires a pressure measurement, the read can be terminated after the ninthbyte for pressure only measurements.
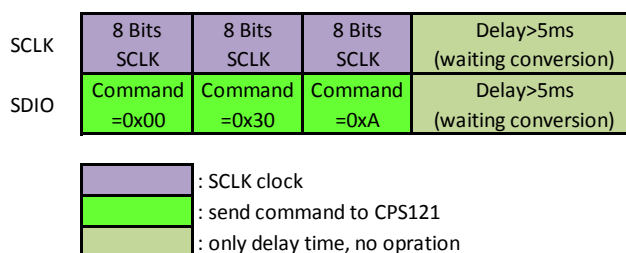
FIGURE 5: SPI GET DATA AFTER MEASUREMENT REQUEST

	: SCLK clock
	: send command to CPS121
	: get data from CPS121
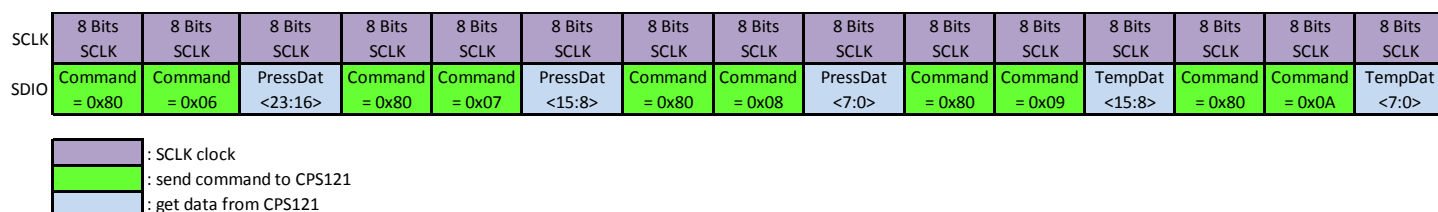
3.6 SPI MEASUREMENT REQUEST (MR)

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

	8 Bits SCLK	8 Bits SCLK	8 Bits SCLK	Delay>5ms (waiting conversion)
SCLK	8 Bits SCLK	8 Bits SCLK	8 Bits SCLK	Delay>5ms (waiting conversion)
SDIO	Command =0x00	Command =0x30	Command =0xA	Delay>5ms (waiting conversion)

	: SCLK clock
	: send command to CPS121
	: only delay time, no opration

4   CALCULATING OUTPUT

After retrieving the data, the compensated output can be scaledto 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:

Pressure [kPa] = (Pressure 3rd Byte [23:16] x 65536+Pressure 2nd Byte [15:8] x 256 + Pressure1st Byte [7:0]) / 2^6/1000

4.2 TEMPERATURE OUTPUT

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

Positive Temperature [°C] = (Temperature High Byte [15:8] x 256 + Temperature Low Byte [7:0]) / 2^8

Negative Temperature [°C] = (Temperature High Byte [15:8] x 256 + Temperature Low Byte [7:0]-65536) / 2^8

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5 PACKAGE AND ASSEMBLY

The CPS121 is available in an 8-pinLGA package.

5.1 PIN ASSEMBLY AND MECHANICAL DRAWING

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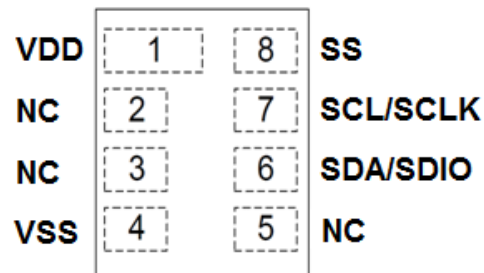
Pin	Name	Function
1	VDD	Power Supply, Connect 0.1uF CAP to GND
2	NC	Not Connect
3	NC	Not Connect
4	VSS	Ground
5	NC	Not Connect
6	SDA/SDIO	I2C Data and SPI data In/Out
7	SCL/SCLK	I2C and SPI Clock
8	SS	=1 or float I2C is selected, =0 SPI is selected

TOP VIEW
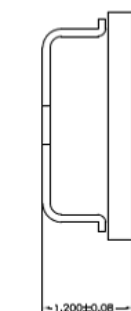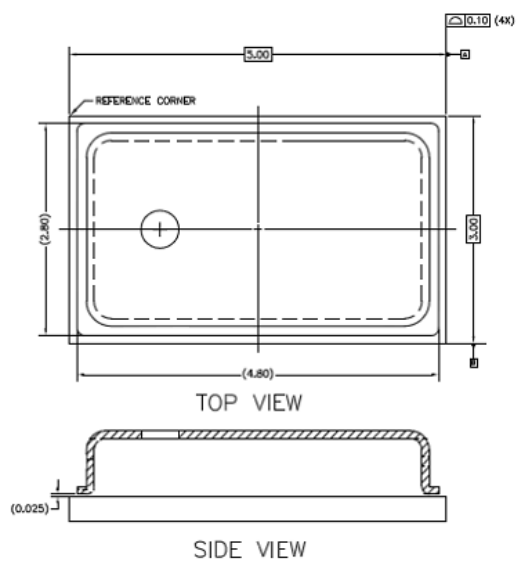
SIDE VIEW

SIDE VIEW
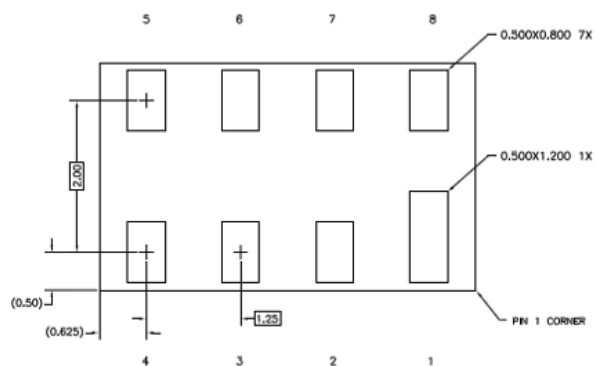
BOTTOM VIEW
8 METAL LANDS

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

6 APPLICATION DIAGRAM

3-wire SPI Mode

2-Wire I2C Mode
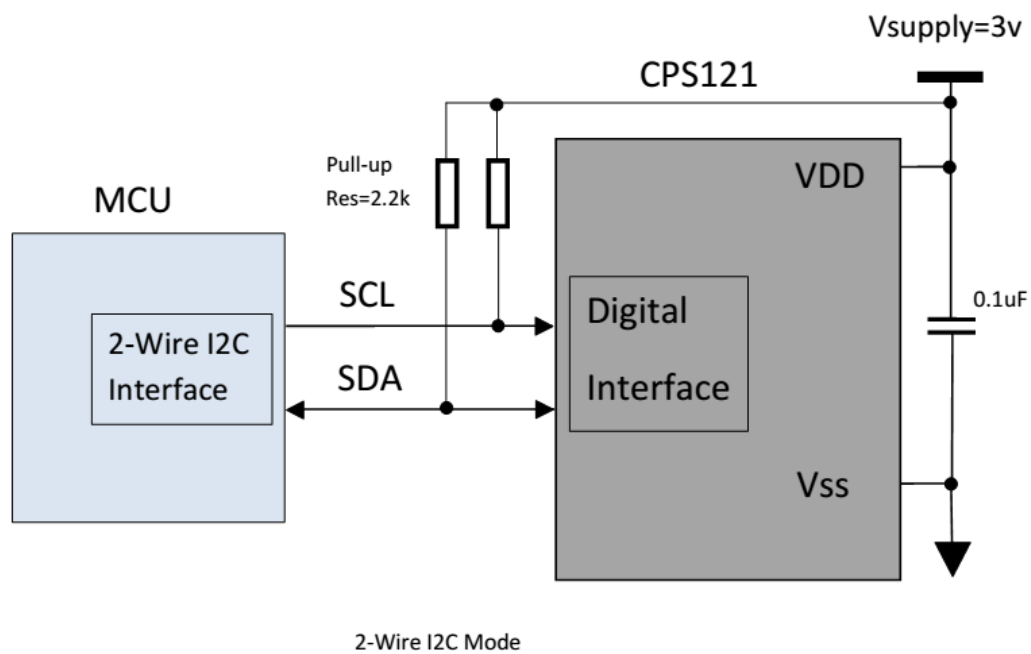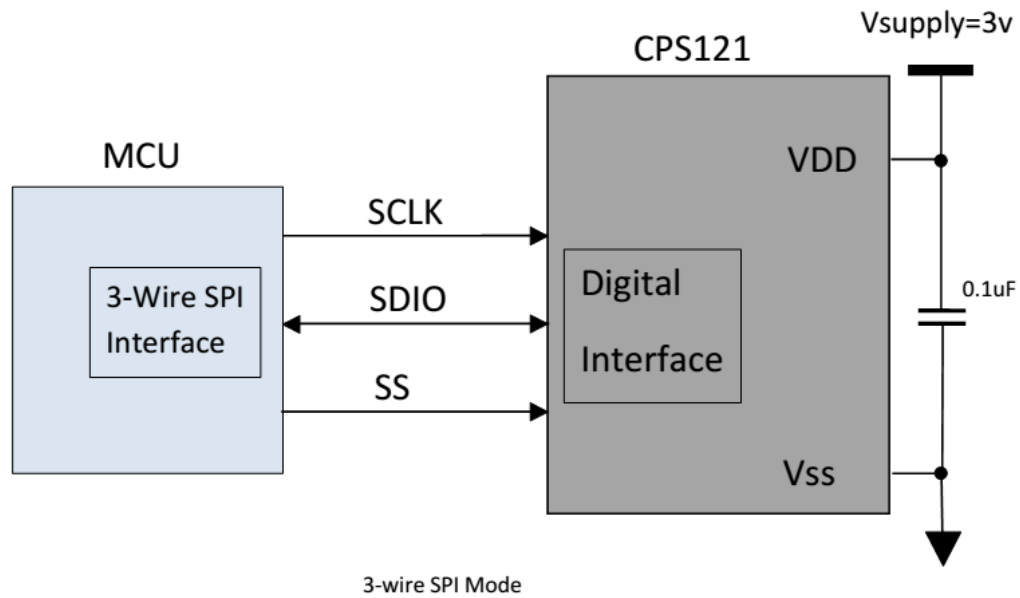
7   DOCUMENT HISTORY

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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