CE211322 - Interfacing the PSoC® Analog Coprocessor with a Humidity Sensor

Objective

This code example demonstrates how to implement an analog front end (AFE) for a humidity sensor, using the PSoC Analog Coprocessor.

Overview

This code example demonstrates how to measure humidity using the capacitance of a humidity sensor. The Cypress CapSense Component is used to measure the capacitance of the humidity sensor. The CapSense Component provides best-in-class signal-to-noise ratio (SNR) (>5:1) for sensors with capacitance up to 200 pF. It also provides high-performance sensing across a variety of environmental factors, such as temperature and humidity.

The measured capacitance and the calculated humidity value are sent over I^2C to a host PC running the Cypress's Bridge Control Panel (BCP) software. The humidity value is used to control the brightness of an LED.

Requirements

Tool: PSoC Creator™ 3.3 CP3 or later versions

Programming Language: C (ARM® GCC 4.9.3)

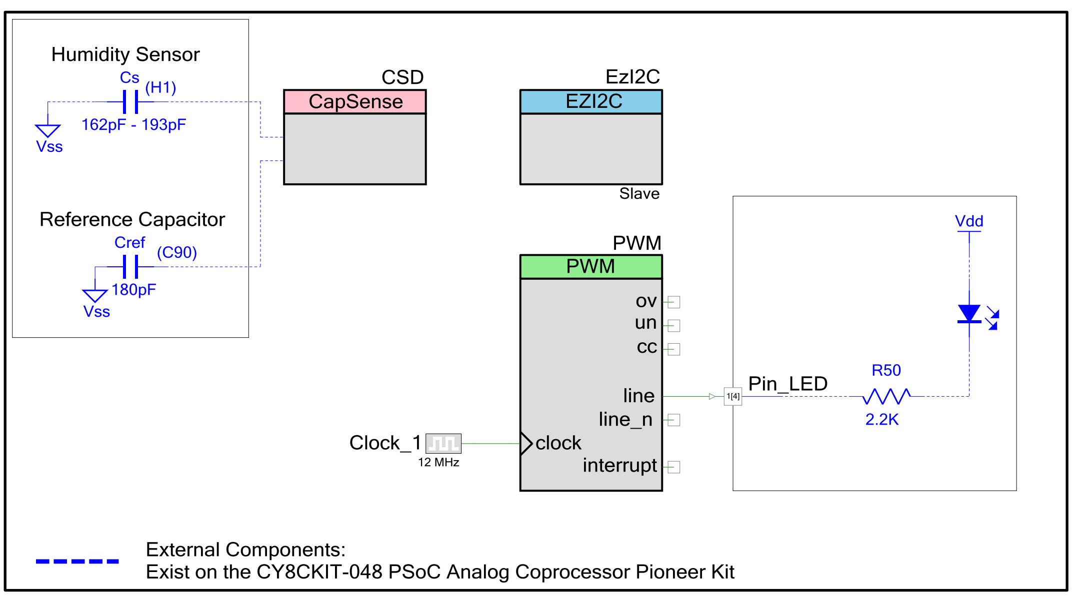
Associated Parts: All PSoC Analog Coprocessor parts

Related Hardware: CY8CKIT-048 PSoC Analog Coprocessor Pioneer Kit

Design

Figure 1 shows the PSoC Creator schematic for interfacing a humidity sensor with the PSoC Analog Coprocessor.

Figure 1. Humidity Sensing Schematic



The CY8CKIT-048 PSoC Analog Coprocessor Pioneer Kit has a humidity sensor (HPP801A031) and a reference capacitor (C_{ref}) of 180 pF. The reference capacitor, C_{ref}, is used to calibrate the capacitance measurement. The capacitance of the humidity sensor is calculated using the following equation:

$$C_s = \frac{C_{ref} * (RawCount_{Cs} - RawCount_{Cos})}{RawCount_{Cref} - RawCount_{Cos}} + C_{OS}$$

Where, C_s is the capacitance of the humidity sensor
C_{ref} is the capacitance of the reference capacitor
$RawCount_{Cs}$ is the raw count obtained from the CapSense Component when the humidity sensor is being measured
$RawCount_{Cref}$ is the raw count obtained from the CapSense Component when the reference capacitor is being measured
$RawCount_{Cos}$ is the raw count that corresponds to the offset capacitance (trace capacitance with sensor disconnected)
C_{OS} is the offset capacitance (trace capacitance with sensor disconnected from the pin)

Humidity is calculated from the measured capacitance, C_s, using the following equation:

$$\%RH = \frac{C_s - C_{nom}}{Sensitivity} + \%RH_{nom}$$

Where, C_S is the capacitance of the humidity sensor
C_{nom} is the nominal capacitance of the humidity sensor
Sensitivity is the sensitivity of the humidity sensor (pF/%RH)
$\%RH_{nom}$ is the nominal humidity value
Note that the C_{nom}, Sensitivity and $\%RH_{nom}$ are specific to the sensors and are provided by the sensor manufacturer. For the humidity sensor (HPP801A031) used on the PSoC Analog Coprocessor Pioneer Kit, the C_{nom}, $\%RH_{nom}$, and Sensitivity are 180 pF, 55%RH, and 0.31 pF/%RH respectively.

The LED intensity varies based on the calculated humidity value. The LED intensity is set to zero for a humidity value less than 50% RH and is gradually increased with increasing humidity value.

In addition to indicating the status on an LED, data such as sensor raw count, measured sensor capacitance, humidity, and reference capacitor raw count is sent to a host PC using I^2C.

The capacitance of the humidity sensor used in this code example varies from 162 pF to 193 pF for 1% to 100% Relative Humidity (RH). The calibration capacitor is selected closer to the upper range of the capacitance measurement to reduce the gain error in measurement. In this code example, the C_{ref} value is 180 pF.

Design Considerations

This design can be adapted to support other capacitance based humidity sensors.

This code example is designed for the PSoC Analog Coprocessor Pioneer kit. The design is easily portable to other kits and PCBs, typically by just changing the sensor and RGB LED pin assignments.

Hardware Setup

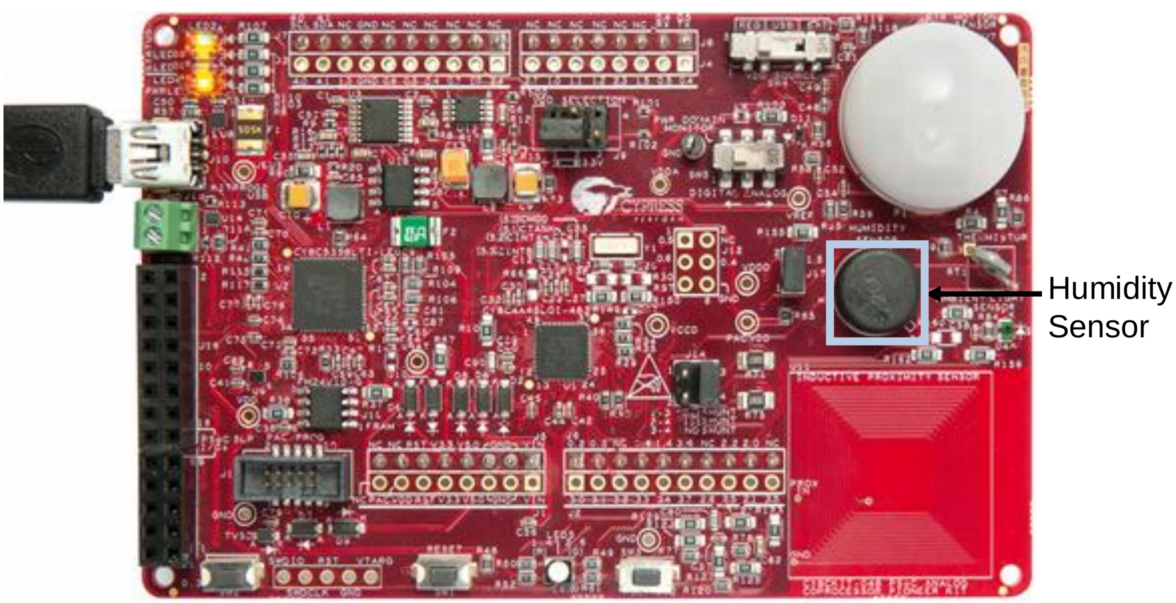
Set the SW4 switch on the PSoC Analog Coprocessor Pioneer Kit to 'REG' position, to select the regulator as the V_{DD} source. Set the jumper J9 to 1-2, for 3.3-V device operation. If you want to use a different power source or a different V_{DD} value, select the SW4 and J9 settings based on Table 1.

Table 1. PSoC Analog Coprocessor Board Power Supply Source and V_{DD} Selection

Power Supply Source	V_{DD} (volts)	SW4 (switch position)	J9 (jumper position)
USB	1.8	REG	open
	3.3	REG	1-2
	5.0	USB	Any position except 2-3
	1.8 - 3.3	REG	4-2
External VIN	1.8	REG	open
	3.3	REG	1-2
	5.0	REG	2-3
Arduino baseboard	1.8	REG	open
	3.3	REG	1-2
Coin Cell	3.0	BAT	NA

Connect the PSoC Analog Coprocessor Pioneer Kit to your computer's USB port, using the USB cable provided with the kit, as Figure 2 shows.

Figure 2. Hardware Connection



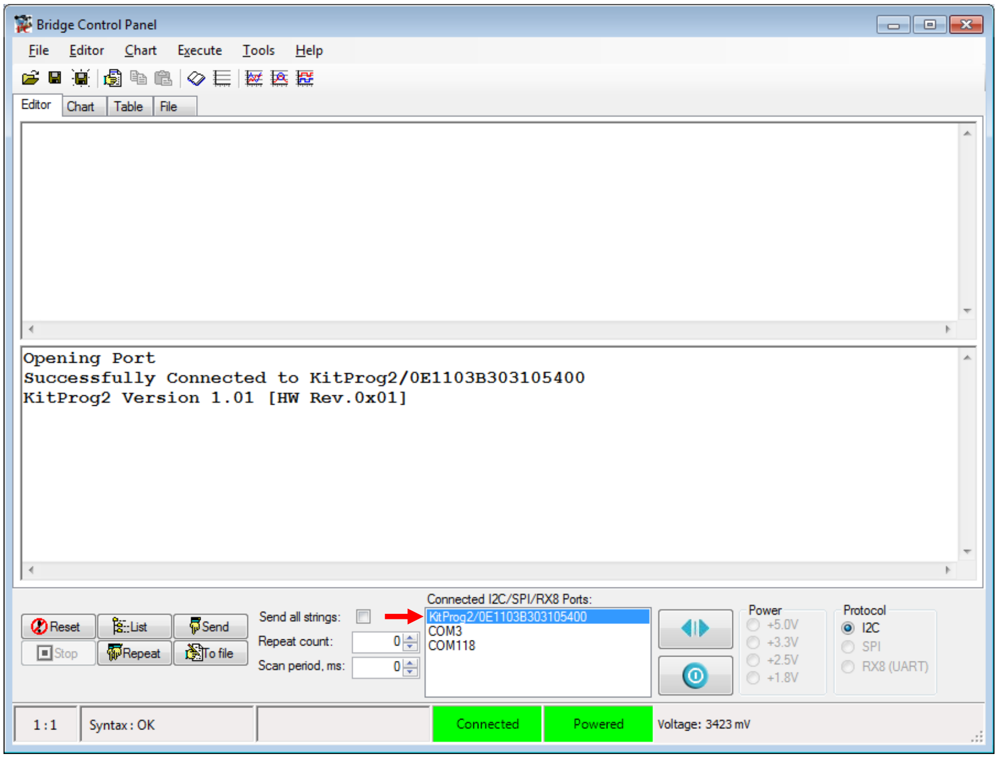
Software Setup

This section describes how to set up the Cypress Bridge Control Panel (BCP) software for viewing sensor data sent over I^2C.

The BCP is installed automatically as part of the kit software installation. Follow these steps to configure the BCP:

1. Open the BCP from: **Start** > **All Programs** > **Cypress** > **Bridge Control Panel <version>** > **Bridge Control Panel <version>.**
2. Select **KitProg2/<serial number>** under **Connected I2C/SPI/RX8 Ports** (see Figure 3). Note that the PSoC Analog Coprocessor Pioneer Kit must be connected to the USB port of your computer.

Figure 3. Bridge Control Panel

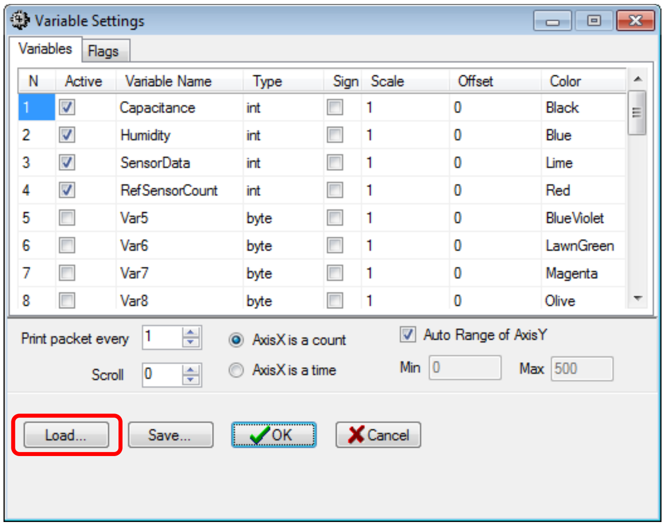


3. Select menu item **Tools** > **Protocol Configuration**, navigate to the **I2C** tab, and set the **I2C speed** to ‘100 kHz’. Click **OK**.

4. Select menu item **Chart** > **Variable Settings** and **Load** the *CE211322_Humidity_Sensing.ini* file from the following path: <Install_Directory>\CY8CKIT-048 PSoC Analog Coprocessor Pioneer Kit\<version>\Firmware\PSoC Analog Coprocessor\BCP Command\. Click **OK**. See
5. Figure 4.

   This file includes the variable names, their data type, and their signs, to represent the data sent over I^2C.

Figure 4. Variable Settings in Bridge Control Panel Software



BCP is now ready for reading and displaying the sensor data. Refer to the Operation for the testing procedure.

Components

Table 2 lists the PSoC Creator Components used in this example as well as the hardware resources used by each.

Table 2. List of PSoC Creator Components

Component	Instance Name	Version	Hardware Resources
CapSense	CSD	V3.0	CapSense Sigma-Delta (CSD)
PWM (TCPWM mode)	PWM	V2.10	Timer Counter Pulse Width Modulator (TCPWM)
EZI2C Slave (SCB mode)	EZI2C	v3.20	Serial Communication Block (SCB)
Digital Output Pin	Pin_LED	v1.20	I/O
Clock	Clock_1	V2.20	Clock

Parameter Settings

Table 3 lists the non-default settings of all the components used in the design.

Table 3. Components Parameters

Component Instance Name	Settings (Non-Default)
CSD	Basic tab: Add one button and change the Sensing element(s) to 2. CSD Tuning mode: Manual tuning Advanced tab > General: Enable IIR filter (First order): Enable Advanced tab > CSD Settings: Sense clock source: Direct Advanced tab > Widget Details: Button0(CSD) > Scan resolution: 16 bits Button0(CSD) > Sense clock frequency (kHz): 187.5
PWM	Period: 1000 Compare: 1000
EzI2C	-
Pin_LED	External terminal: Enabled
Clock_1	-

Note EzI2C pins are embedded within the Component

Design-Wide

Table 4 lists the physical pins used.

Table 4. Pin Names and Locations

Pin Name	Location
EzI2C:SCL	P4[0]
EzI2C:SDA	P4[1]
CSD:Cmod	P5[0]
CSD:Sns [0] (Humidity Sensor)	P1[5]
CSD: Sns [1] (RefSensor)	P1[7]
Pin_LED	P1[4]

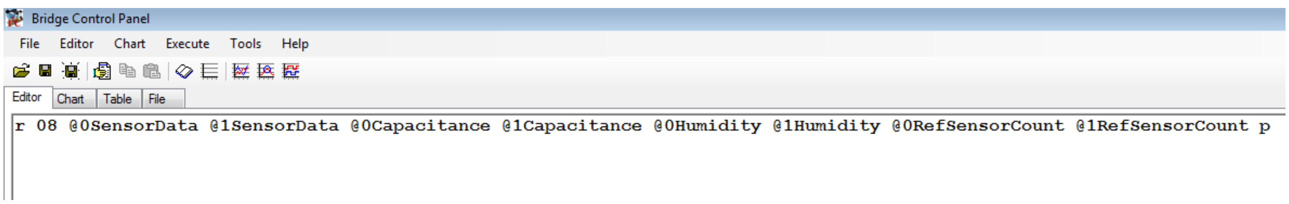
Operation

Follow these steps:

1. Select the *CE211322_Humidity_Sensing.cywrk* file in the PSoC Creator Start page under **Examples and Kits** > **Kits** > **CY8CKIT-048**. Select a location to save the code example.
2. Build the project; select the PSoC Creator menu item **Build** > **Build CE211322_Humidity_Sensing**.
3. Connect the PSoC Analog Coprocessor Pioneer Kit to your computer's USB port, as described in the section Hardware Setup.
4. Program the PSoC Analog Coprocessor device; select **Debug** > **Program**.
5. Configure the BCP software as described in the section Software Setup.
6. Select **File** > **Open File**. Open the *CE211322_Humidity_Sensing.iic* file from the following path:
   <Install_Directory>\CY8CKIT-048 PSoC Analog Coprocessor Pioneer Kit\<version>\Firmware\PSoC Analog Coprocessor\BCP Command\

   This file contains the read command to be executed from BCP. The command appears on the panel, as Figure 5 shows.

   Figure 5. Read Command in the Bridge Control Panel

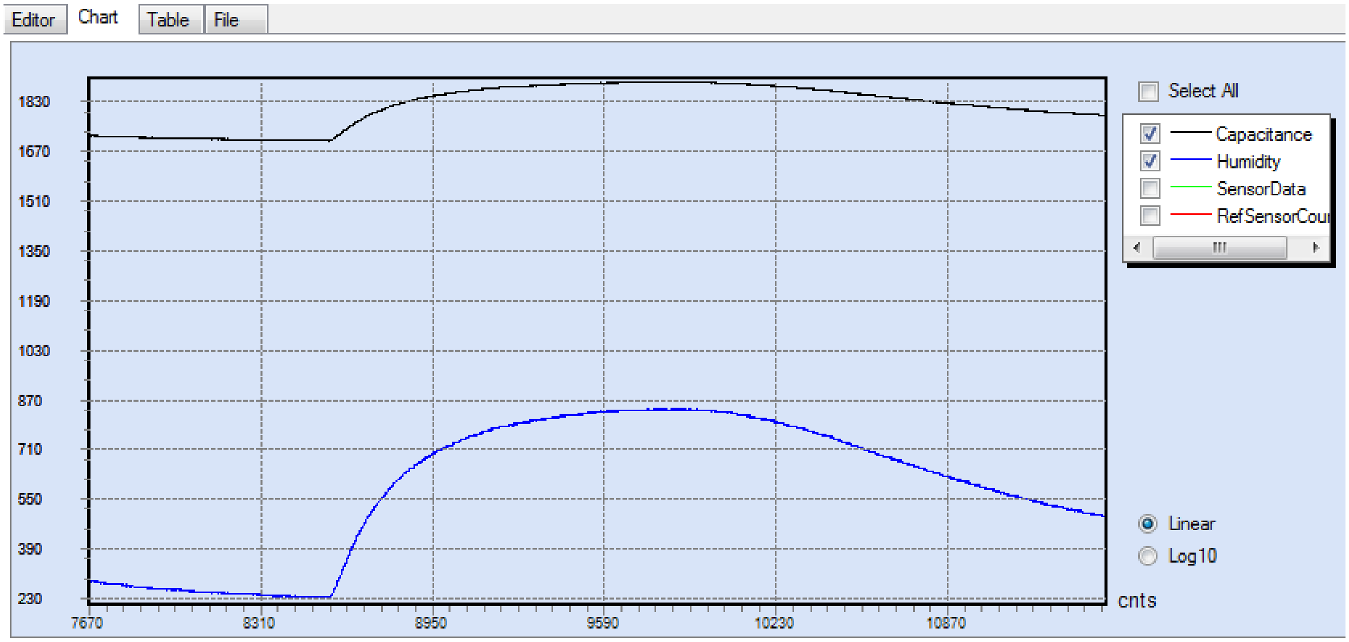
7. Click on the read command on the **Editor** tab in BCP and then click the **Repeat** button to read the sensor data continuously. Go to the **Chart** tab and observe the sensor raw count by selecting only the *SensorData* variable.
8. Remove the jumper J17 to disconnect the humidity sensor from PSoC Analog Coprocessor. This is required to get the offset count that corresponds to the parasitic capacitance of the trace that connects humidity sensor to PSoC Analog Coprocessor.
9. Observe the instantaneous sensor raw count and calculate the average value of sensor raw count using the following equation.

   Average raw count = (Maximum raw count + Minimum raw count) / 2
10. Assign the average raw count calculated in step 9 to the macro `OFFSETCOUNT` in the *main.c* file.
11. Now reconnect the jumper J17.
12. Build the project by selecting menu item **Build > Build CE211322_Humidity_Sensing**.
13. Program the PSoC Analog Coprocessor device by selecting menu item **Debug** > **Program**.

    Note: Disconnect the **KitProg2/<serial number>** under **Connected I2C/SPI/RX8 Ports** in BCP in order to program the device.
14. In the BCP, click the **Repeat** button again and observe the plot of the four values – sensor capacitance, humidity, sensor raw count, and reference capacitor raw count – that are read from the PSoC Analog Coprocessor device. See Figure 6.

Note that the sensor capacitance and humidity values are scaled by 10 and displayed on the BCP.

Figure 6. Bridge Control Panel Chart



15. Blow air gently on the humidity sensor H1 and observe that the intensity of the red LED varies when the calculated humidity value is greater than 50%.

Related Documents

Table 5 lists all relevant application notes, device datasheets, technical reference manuals, Component datasheets, and development kits.

Table 5. Related Documents

Application Notes		
AN211293	Getting Started with PSoC Analog Coprocessor	Describes the PSoC Analog Coprocessor.
PSoC Creator Component Datasheets		
CapSense	Supports Capacitive touch sensing applications	
EZI2C Slave	Simplified I2C slave implementation	
Pins	Supports connection of hardware resources to physical pins	
PWM	Supports Timer, Counter and PWM functions	
Device Documentation		
PSoC Analog Coprocessor Datasheets		
PSoC Analog Coprocessor Architecture Technical Reference Manual		
PSoC Analog Coprocessor Register Technical Reference Manual		
Development Kit (DVK) Documentation		
CY8CKIT-048 PSoC Analog Coprocessor Pioneer Kit		

Document History

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Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	5301287	DIMA	06/10/2016	New code example.

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