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AEK-CY8C20xx7

QuietZone™ CapSense® Starter Kit User Guide

Contents

1. Introduction

Thank you for your interest in the AEK-CY8C20xx7 QuietZone™ CapSense® Starter Kit. This document explains how to develop best-in-class capacitive touch sensing solutions using the QuietZone family of CapSense controllers.

1.1 Kit Contents

- AEK-CY8C20xx7 board with CY8C20247S-24LKXI
- 5-pin connector

1.2 Additional Requirements

- Hardware
  - MiniProg3
  - USB A to Mini-B cable
  - Connecting wires and copper tape
  - Soldering iron
- Software
  - PSoC® Designer™ (version 5.2 or higher)
  - PSoC® Programmer™ (version 3.14 or higher)
  - Bridge Control Panel

1.3 Cypress's CapSense Controller - CY8C20247S-24LKXI Features

The Cypress CY8C20247S-24LKXI is a low-power, high-performance, programmable CapSense controller offered in a 16-pin QFN (3 mm x 3 mm).

1.3.1 Advanced Touch Sensing Features

- Programmable capacitive sensing elements
  - Supports a combination of CapSense buttons, sliders, and proximity sensors
  - Integrated API to implement buttons and sliders
  - Supports up to 10 capacitive sensors and two sliders
  - Supports a parasitic sensor capacitance range of 5 pF to 45 pF
- SmartSense™ Auto-tuning enables fast time-to-market
  - Sets and monitors tuning parameters automatically at power-up and at runtime
  - Design portability – self-tunes for changes in the user's design
  - Environmental compensation during runtime
  - High sensitivity - 0.1 pF

- Enhanced noise immunity and robustness
  - SmartSense_EMCplus™ automatically compensates for environmental and manufacturing variations
  - SmartSense_EMCplus offers superior noise immunity for applications with challenging conducted and radiated noise conditions
  - Internal regulator provides stability against power supply noise
  - Integrated API of software filters, which improve signal-to-noise ratio (SNR)
- Ultra low-power consumption
  - Three different power modes for optimized power consumption
  - Active, sleep, and deep-sleep modes (deep-sleep current: 100 nA)
  - 28 µA per sensor at 125 ms wake from sleep rate

1.3.2   Device Features

- High-performance, low-power M8C Harvard-architecture processor
  - Up to 4 MIPS with 24-MHz internal clock
- Flexible on-chip memory
  - 16 KB of flash and 2 KB of SRAM
  - Emulated EEPROM supported
- Precision, programmable clocking
  - Internal main oscillator (IMO): 6/12/24 MHz ± 5%
  - Option for precision 32-kHz external crystal oscillator
- Enhanced general-purpose input output (GPIO) features
  - 10 general-purpose I/Os (GPIOs) with programmable pin configuration
  - 25-mA sink current/GPIO and 120-mA total sink current/device
  - Internal restive pull-up, Hi-Z, open-drain, and strong drive modes on all GPIOs
- Peripheral features
  - Three 16-bit timers
  - I2C – master (100 kHz) and slave (400 kHz)
  - SPI – master and slave – configurable range: 46.9 kHz to 12 MHz
  - 10-bit incremental ADC input range: 0 to 1.2 V
- Operating conditions
  - Wide operating voltage: 1.71 V to 5.5 V
  - Temperature range: –40 °C to +85 °C

1.4   Factory Default Configuration

The AEK-CY8C20xx7 QuietZone CapSense Starter kit board is not pre-programmed; the entire flash memory of the CY8C20247S-24LKXI is available.

1.5 Additional Educational Resources

Visit http://www.cypress.com for additional educational resources, including Datasheets, Design Guides, Technical Reference Manuals, and Application Notes.

- CY8C20247S-24LKXI
  - ❒ Datasheet - http://www.cypress.com/?rID=59671
  - ❒ Design Guide - http://www.cypress.com/?rID=63035
  - ❒ Getting Started with CapSense - http://www.cypress.com/?rID=48787
  - ❒ Technical Reference Manual - http://www.cypress.com/?rID=59964
  - ❒ Application Note: Host Sourced Serial Programming - http://www.cypress.com/?rID=42958
- PSoC Designer overview and latest releases - http://www.cypress.com/go/psocdesigner
- MiniProg3 overview and latest releases - http://www.cypress.com/?rID=38154

1.6 Documentation Conventions

Convention	Usage
Courier New	Displays file locations, user-entered text, and source code: `C:\ ...cd\icc\`
Italics	Displays file names and reference documentation: Read about the *sourcefile.hex* file in the *PSoC Designer User Guide*.
[**Bracketed, Bold**]	Displays keyboard commands in procedures: [**Enter**] or [**Ctrl**] [**C**]
File > Open	Represents menu paths: File > Open > New Project
Bold	Displays commands, menu paths, and icon names in procedures: Click the **File** icon and then click **Open**.
Times New Roman	Displays an equation: $2 + 2 = 4$
Text in gray boxes	Describes cautions or unique functionality of the product.

2. Software

This chapter describes how to install the software required to operate the AEK-CY8C20xx7 QuietZone CapSense Starter Kit.
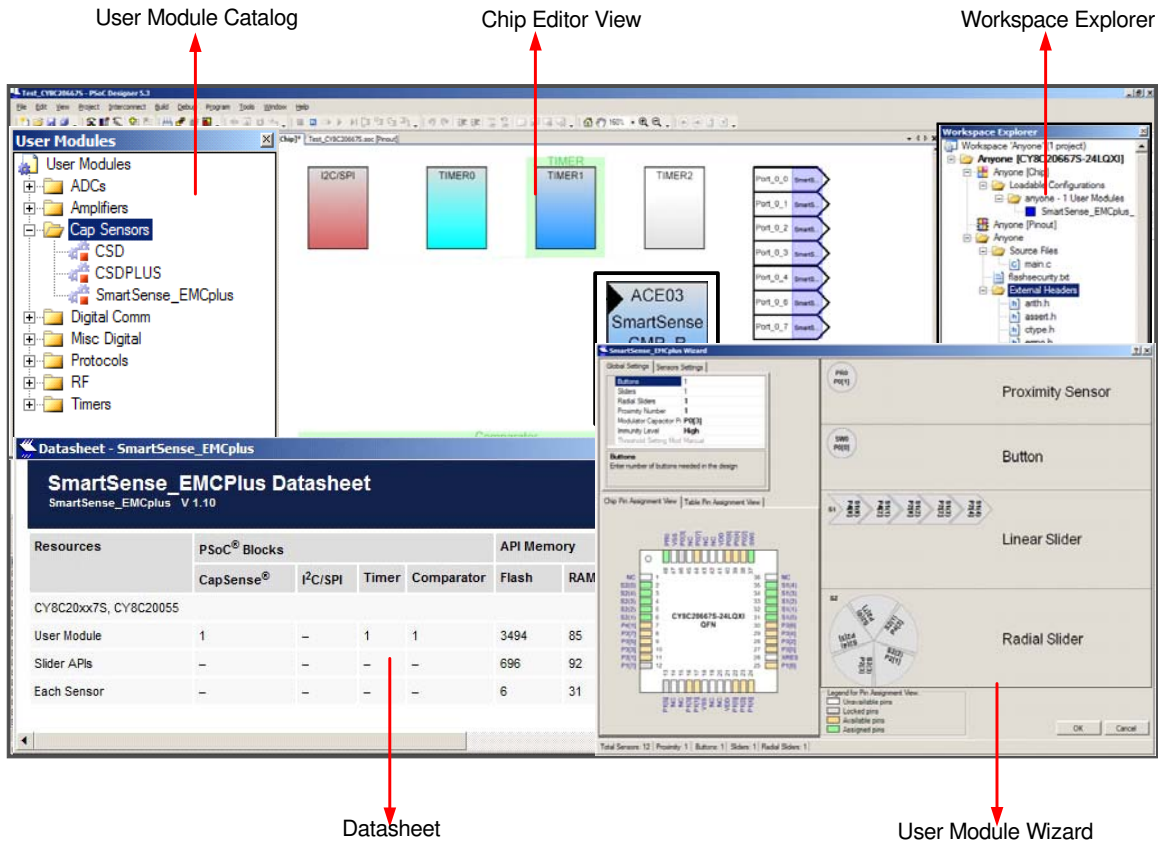
2.1 PSoC Designer

Cypress's PSoC Designer is a revolutionary integrated design environment (IDE) that you can use to customize PSoC to meet your specific application requirements. You can develop applications using a library of pre-characterized analog and digital peripherals in a drag-and-drop design environment. Then, customize your design using the dynamically generated API code libraries. Finally, debug and test your designs with the integrated debug environment, including in-circuit emulation and standard software debug features.

Download PSoC Designer for free from http://www.cypress.com/go/psocdesigner.

1. To open the application, click **Start** > **All Programs** > **Cypress** > **PSoC Designer <version>** > **PSoC Designer <version>**.

2. Click **File** > **New Project** to create a new project; click **File** > **Open Project** to work with an existing project.

3. To experiment with the example projects, go to the .

Figure 2-1. PSoC Designer Interconnect View

User Module Catalog   Chip Editor View   Workspace Explorer

Datasheet   User Module Wizard

Note For more details on PSoC Designer, see the PSoC Designer IDE Guide located at:

`<Install_Directory>\Cypress\PSoC Designer\<version>\Documentation`

See Additional Educational Resources on page 6 for links to PSoC Designer training. The PSoC Designer Quick Start Guide is available at http://www.cypress.com/?rID=47954.

2.2   PSoC Programmer

PSoC Programmer is a stand-alone utility for programming PSoC devices.

1. Click **Start** > **All Programs** > **Cypress** > **PSoC Programmer <version>** > **PSoC Programmer <version>**.

2. Select the MiniProg from **Port Selection**, as shown in Figure 2-2.

Figure 2-2. PSoC Programmer Window
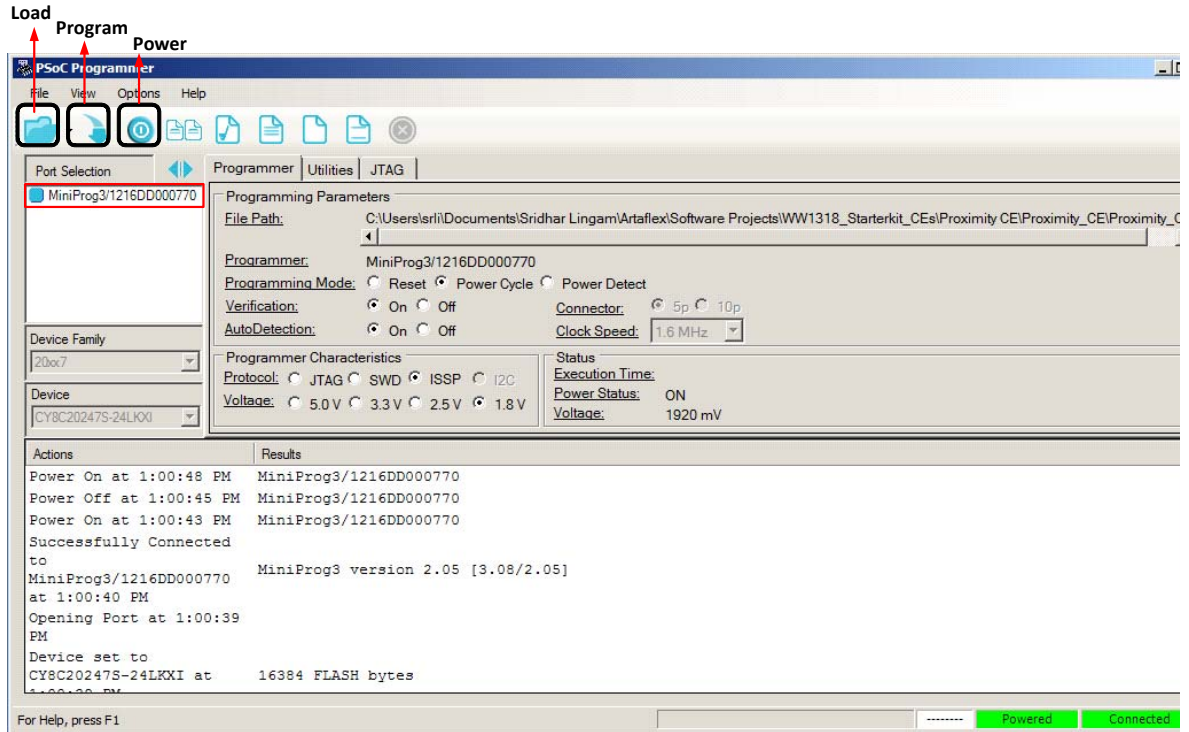
3. Click the **File Load** button to load the hex file.

4. Use the **Program** button to program the hex file onto the chip.

5. When programming is successful, "Programming Succeeded" appears in the Actions pane.

6. Close PSoC Programmer.

Note For more details on PSoC Programmer, see the user guide at the following location:

`<Install_Directory>\Program Files\Cypress\Programmer\<version>\Documents`

2.3 CapSense Data Viewing Tools

During the CapSense design process, you need to monitor the sensor data, such as raw counts, baseline, and difference counts, for tuning and debugging. The Bridge Control Panel application collects and charts the data using the I^{2}C communication interface.

2.3.1 Bridge Control Panel (BCP)

The Bridge Control Panel is used with the MiniProg3 to enable communication with I^{2}C slave devices. This program configures I^{2}C devices and acquires and processes data received from the I^{2}C slave devices. The Bridge Control Panel helps to optimize, debug, and calibrate the target applications.

The main features of the application are:

■ Controls the power supply of connected devices

■ Supports the I^{2}C protocol

■ Searches and displays a list of devices connected to the bridge

■ Supports high-speed data reading from the slave device (ToFile mode of bridge)

To open the application, click **Start** > **All Programs** > **Cypress** > **Bridge Control Panel <version>**.

Figure 2-3. Bridge Control Panel Window
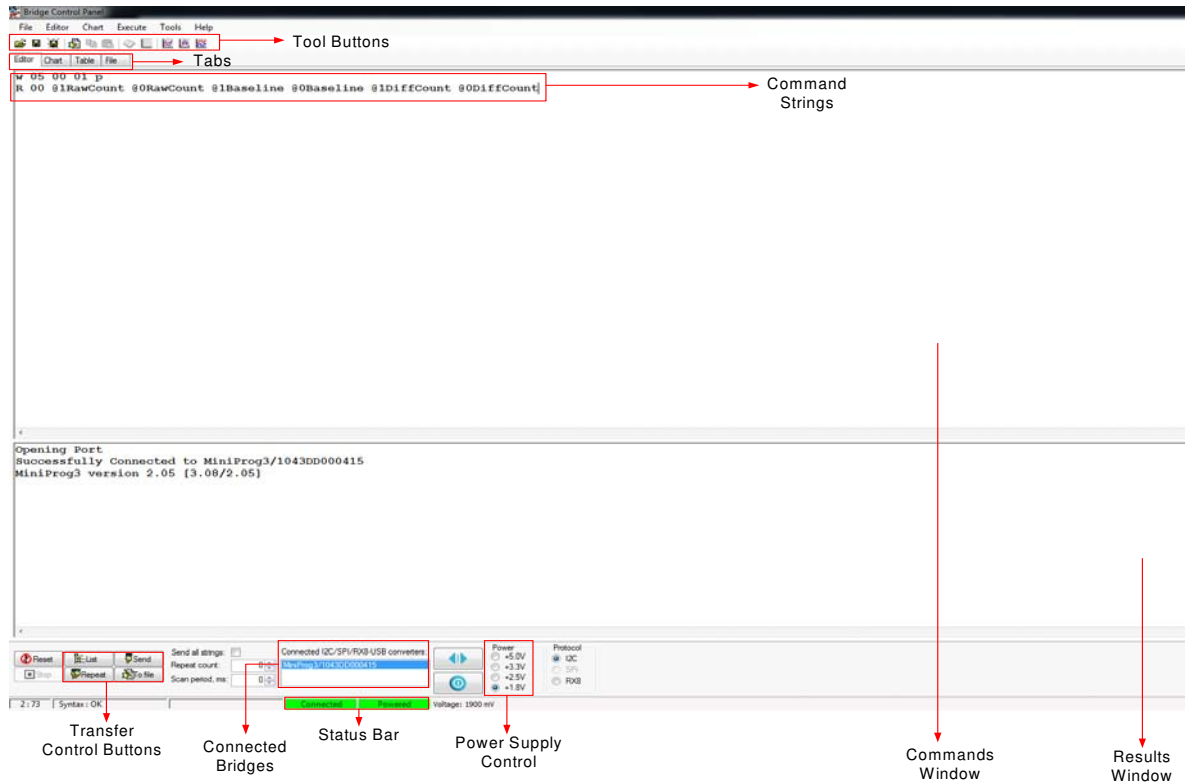
Note See Cypress Application Note AN2397: CapSense Data Viewing Tools for additional details.

2.4   Example Projects

The example projects are available in a zip file for free download from
http://www.artaflexmodules.com/quietzone.

The zip file contains three PSoC Designer example projects that implement a button, a slider, and proximity sensing using the CY8C20xx7. The example projects can be extracted to any directory of your choice and will be referred as 'Projects Directory' in this document. The example projects folders also contain Bridge Control Panel configuration files, which can be used to read the CapSense data using the Bridge Control Panel tool.

The example projects provided with the AEK-CY8C20xx7 QuietZone CapSense Starter Kit are:

- **Proximity with CY8C20xx7**

    This example project uses the CSDPLUS user module to implement proximity sensing using a wire loop sensor. The example project uses the EzI2Cs user module to transmit the required CapSense parameters. The CapSense data can be viewed on a PC using the Bridge Control Panel tool.

- **Button with CY8C20xx7**

    This example project uses the SmartSense_EMCplus user module to implement a CapSense button. SmartSense Auto-tuning tunes the sensor automatically at power-up; it then monitors and maintains optimum sensor performance during runtime. The example project uses the EzI2Cs user module to transmit the required CapSense parameters. The CapSense data can be viewed on a PC using the Bridge Control Panel tool.

- **Slider with CY8C20xx7**

    This example project uses the SmartSense_EMCplus user module to implement a five-segment slider. The example project uses the EzI2Cs user module to transmit the required CapSense parameters. The CapSense data can be viewed on a PC using the Bridge Control Panel tool.

The Proximity with CY8C20xx7 example project is explained in detail in Getting Started with the Proximity Sensor Project on page 16. For an explanation of the Button with CY8C20xx7 and Slider with CY8C20xx7 example projects, see the Example Projects chapter on page 26.

3. Kit Operation

The AEK-CY8C20xx7 QuietZone CapSense Starter Kit enables the evaluation of the CY8C20247S-24LKXI. The kit has a 5-pin header to connect with the Cypress MiniProg3. You can either build your own sensor board or use connecting wire and copper tape to quickly evaluate the CY8C20247S-24LKXI in your systems. You can achieve proof-of-concept designs, then spin a PCB for the next level of development cycle.

3.1 Hardware Requirements

- AEK-CY8C20xx7 QuietZone CapSense Starter Kit with CY8C20247S-24LKXI
- 5-pin connector for ISSP header
- MiniProg3
- CY3240-I2USB bridge (optional)
- USB A to Mini-B cable

3.2 Connecting CapSense Hardware

The AEK-CY8C20xx7 QuietZone CapSense Starter Kit has a 14-pin edge connector, which includes 10 GPIOs, VDD, GND, and two LED pins. You can directly connect the button and slider hardware to any of the available GPIOs. If your designs lack hardware, you can still configure buttons, sliders, and proximity sensors by connecting GPIOs directly to copper tape cut in the desired shape. This section describes common UI configurations using connecting wire and copper tape. Table 3-1 gives a couple of examples of copper tape that can be purchased from Digi-Key, an online catalog distributor.

Table 3-1. Example Copper Tape Part Numbers

Part Number	Digi-Key Part Number	Digi-Key Description
3M1125C-1YD	3M1125C-1YD-ND	TAPE COPPER FOIL 25.40X914.4MM
3M1125D-1FT	3M1125D-1FT-ND	TAPE COPPER FOIL 152.4X304MM

3.2.1 Proximity Sensors

A proximity sensor can detect the presence of nearby objects without any physical contact. The sensor may be a copper pad, PCB trace, or a wire loop, as defined in Getting Started with the Proximity Sensor Project on page 16, and is tuned for higher sensitivity than touch sensing.

Figure 3-1. A Proximity Sensor Implementation Using Copper Tape as a PCB Trace

Figure 3-2. A Proximity Sensor Implementation Using a Wire Loop

3.2.2   Buttons

A button is a copper sensor connected directly to a CapSense I/O. The simplest capacitive sensor consists of a circular pad built from the copper tape. This circular copper pad is then connected directly with a connecting wire to a CapSense I/O available via the 14-pin edge connector. Optionally, scotch tape can be used as an overlay to cover the sensor. Other examples of overlays are clear plastic or glass up to 5 mm in thickness.

Figure 3-3. A Simple ~10-mm-Diameter Button Using Copper Tape
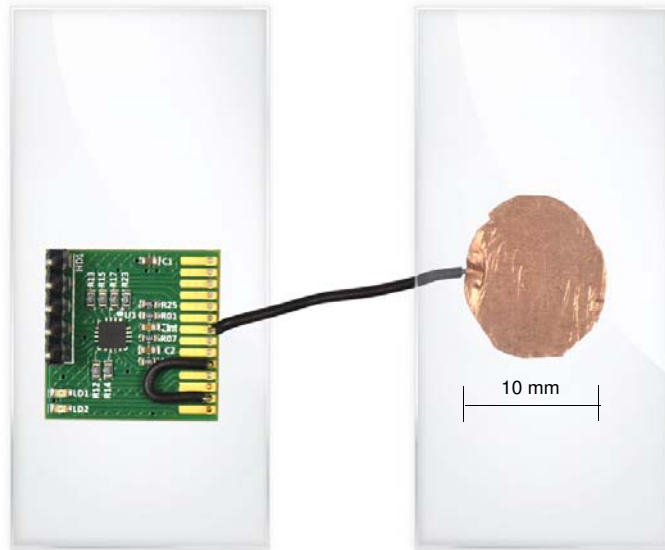
3.2.3 Sliders

Sliders are used for controls requiring gradual adjustments. Examples include lighting control (dimmer), volume control, graphic equalizer, and speed control. A simple linear slider is built using an array of capacitive sensors called segments that are placed adjacent to one another. The capacitive sensors can be in a rectangular shape and built from the copper tape. These sensors can then be connected directly to the CapSense controller I/O pins assigned in firmware to drive these segments. Optionally, scotch tape can be used as an overlay to cover the sensor. Other examples of overlays are clear plastic or glass up to 5 mm in thickness.

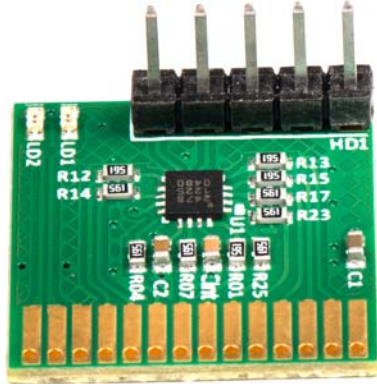Figure 3-4. Slider Implementation Using Copper Tape
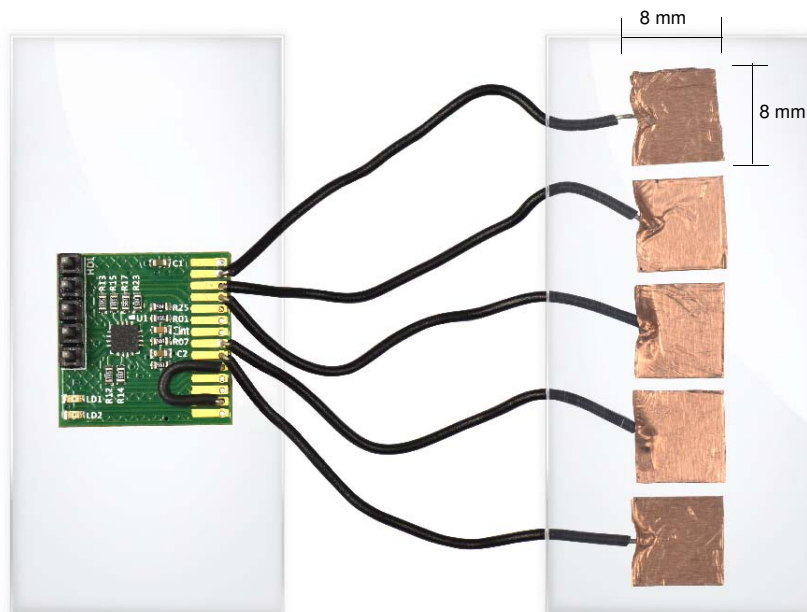
Refer to Getting Started with CapSense for design guidelines of CapSense buttons, sliders, proximity sensors, and LEDs for visual touch feedback.

3.3   Programming CY8C20247S-24LKXI

1. Solder the 5-pin connector directly to the HD1 header of the starter kit.

Figure 3-5. Starter Kit with 5-pin Connector

2. Connect the USB port of your PC to the AEK-CY8C20xx7 ISSP connector using the MiniProg3 and USB A to Mini-B cable.

Figure 3-6. Connect the MiniProg3 Programmer

3. Launch PSoC Programmer by clicking **Start > All Programs > Cypress > PSoC Programmer <version> > PSoC Programmer <version>**.

4. Using the PSoC Programmer software, program the CY8C20247S-24LKXI with the hex file for the proximity sensor project located at: `<Projects Directory>\StarterKit_Example Projects\Proximity with CY8C20xx7\Proximity_with_CY8C20xx7\Proximity_ with_CY8C20xx7.hex`

Figure 3-7. PSoC Programmer
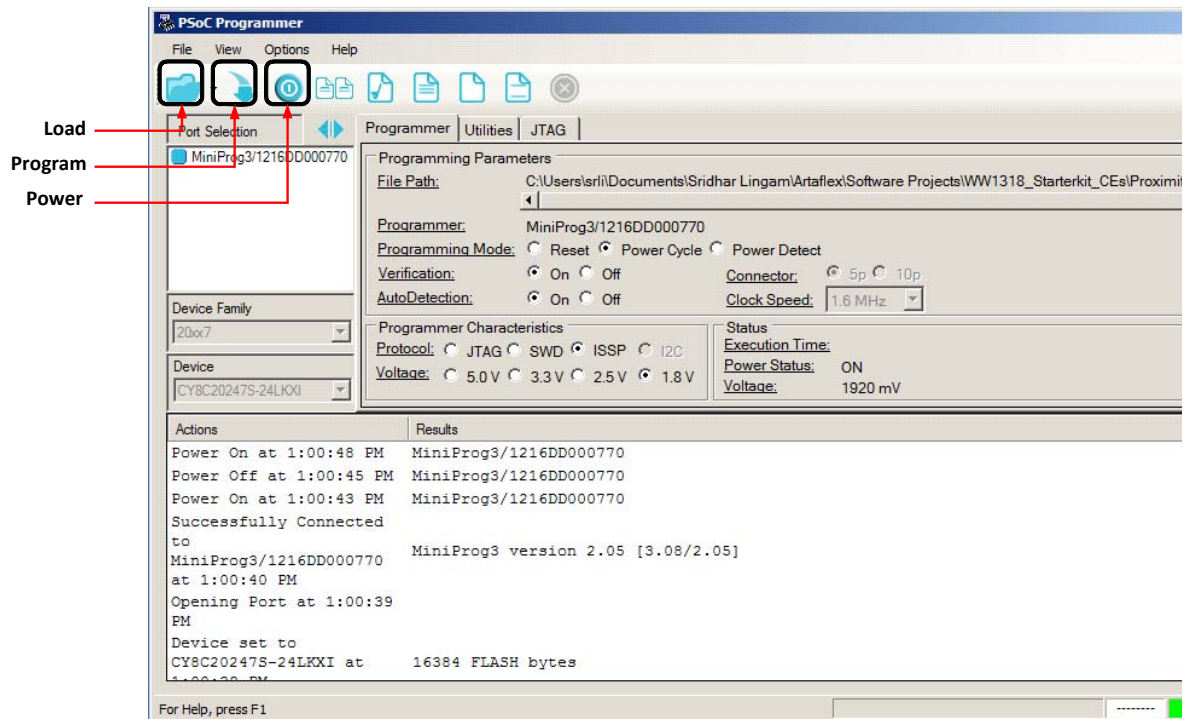
5. After the "Programming Succeeded" message appears in the Actions pane, reset the device by clicking the **Power** button twice to turn the device off and on.

3.4   Getting Started with the Proximity Sensor Project

Follow the steps in Programming CY8C20247S-24LKXI on page 15 and select the proximity sensor project. This example project demonstrates the proximity-sensing capabilities of the QuietZone controller family and enables you to quickly evaluate the AEK-CY8C20xx7 QuietZone CapSense Starter Kit.

The prerequisites for this example are:

■ USB A to Mini-B cable

■ MiniProg3

■ Two connecting wires

■ Soldering iron

Figure 3-8. Proximity Project Prerequisites

The pin assignments used in this example project are:

■ Proximity sensor (wire loop) - P2[3]

■ LED - P1[4]

You can assign any available pin on the 14-pin edge connector for the wire sensor, using the CSDPLUS User Module Wizard. Refer to the user module datasheet, accessible through PSoC Designer, for information about configuring pins using the User Module Wizard.

■ To open PSoC Designer, click **Start > All Programs > Cypress > PSoC Designer <version> > PSoC Designer <version>**.

■ Click **File > Open Project**. Browse to `<Projects Directory>\StarterKit_Example Projects\Proximity with CY8C20xx7\proximity_with_CY8C20xx7 \proximity_with_CY8C20xx7.app`

3.4.1 Firmware Operation

■ Global interrupts are enabled and the CSDPLUS User Module is started.

■ All sensors are scanned continuously in an infinite loop.

■ Filters (median, average, and IIR) are enabled to improve performance against noise.

■ When a valid proximity event is detected, the corresponding LED (LD1 in this example) is switched on; the LED is switched off when the detected object moves out of the detection range. Please note LD1 and LD2 indicate physical LED, while LED1 and LED2 indicate corresponding pins on the 14-pin edge connector.

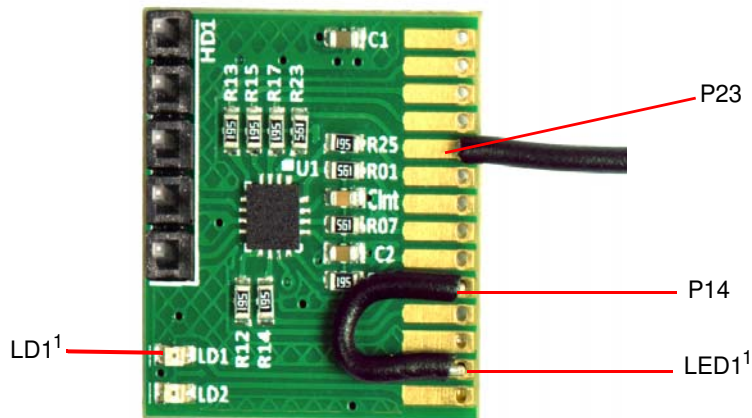### 3.4.2 Running the Example Project

1. Coil the connecting wire to form a loop of ~3 cm in diameter.

Figure 3-9. Wire Loop

2. Solder the wire loop to pin labeled P23 on the 14-pin edge connector and solder together the pins labeled LED1[1] and P14 with another connecting wire.

Figure 3-10. Starter Kit Connections

3. Set voltage to 1.8 V and click on the **Power** button in PSoC Programmer to power the starter kit. See Figure 3-11.

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1. The two pins on the 14-pin edge connector that provide connections to the LEDs are labeled LED1 and LED2. These labels are located on the back side of the kit. The two LEDs on the front side of the starter kit are labeled LD1 and LD2.

Figure 3-11. PSoC Programmer Settings
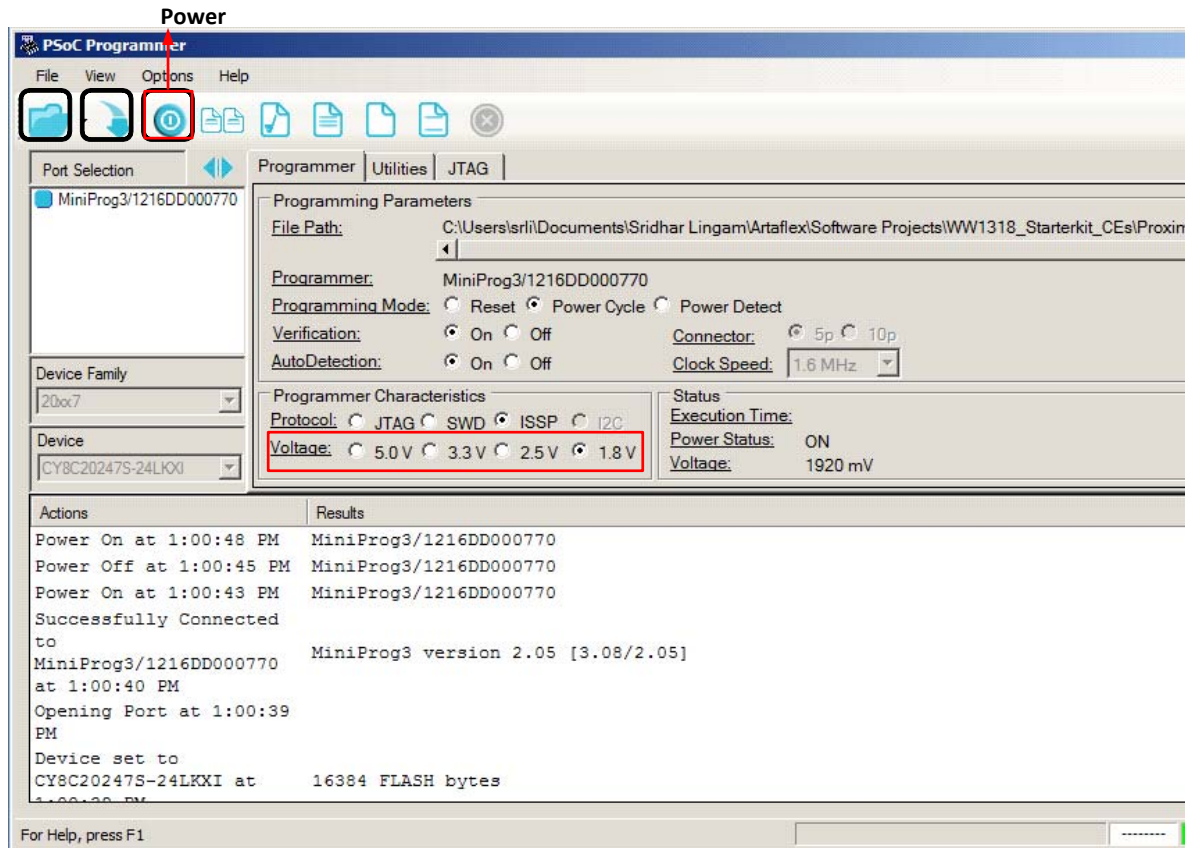
Power

Figure 3-12. Starter Kit with MiniProg3

4. Move your hand toward the loop; when your hand is within the proximity detection range, the LED LD1 will turn on. This example project enables a proximity detection distance of approximately 3 cm. Make sure that the wire loop is coplanar with the starter kit to ensure optimal proximity sensing.

Figure 3-13. LED Glows on Proximity Detection

3.5 Monitoring Sensor Data Using the Bridge Control Panel

The proximity sensor project uses the I²C as the communication interface to output CapSense parameters. The MiniProg3 is used as the I²C-USB bridge to read CapSense parameters from the AEK-CY8C20xx7 QuietZone CapSense Starter Kit. To view these parameters, use the Bridge Control Panel application. Follow these steps to use the Bridge Control Panel with the AEK-CY8C20xx7 QuietZone CapSense Starter Kit.

1. Click **Start** > **All Programs** > **Cypress** > **Bridge Control Panel <version>**.
2. Select the device to be connected from the Port Selection window.
3. Select the **Variable Settings** option from the Chart menu.
4. Upload the .ini file by clicking the **Load** button. The variable setting file, *Proximity_with_CY8C20xx7.ini*, is available in the folder `<Projects Directory>\Starterkit_Example Projects\Proximity with CY8C20xx7\BCP Configuration Files`.
5. Upload the .iic file for iic commands that can be sent to the board. The configuration setting file, *Proximity_with_CY8C20xx7.iic*, is available in the folder `<Projects Directory>\Starterkit_Example Projects\Proximity with CY8C20xx7\BCP Configuration Files`.
6. Go to **File** > **Open File** > **Proximity_with_CY8C20xx7.iic** to select the file for iic commands.
7. Select **+1.8 V** in the Power Settings box.
8. Click **Toggle Power** to power the MiniProg3.
9. Click on the 'W' line, then click on **Send** to send the I2C write instruction `W 00 00 00` once.
10. Click on the 'R' line, then click on **Repeat** to send the following I2C read instruction continuously:
    ```
    R 00 @Sensor_lndex @1RawCount @0RawCount @1Baseline @0Baseline
    @1DiffCount @0DiffCount @SensorStatus
    ```

11. Click the **Chart** tab to view the raw count, baseline, and difference count of the wire sensor.

12. View the required parameters by selecting or clearing the check boxes to the right of the Chart view.

13. Click **Stop** to stop receiving data from the slave device.

14. Click the **Table** tab to view the values of the demonstration board variables.

Note Disconnect the MiniProg3 in PSoC Programmer by clicking on the disconnect icon before opening the Bridge Control Panel.

Figure 3-14. Bridge Control Panel with CapSense Data
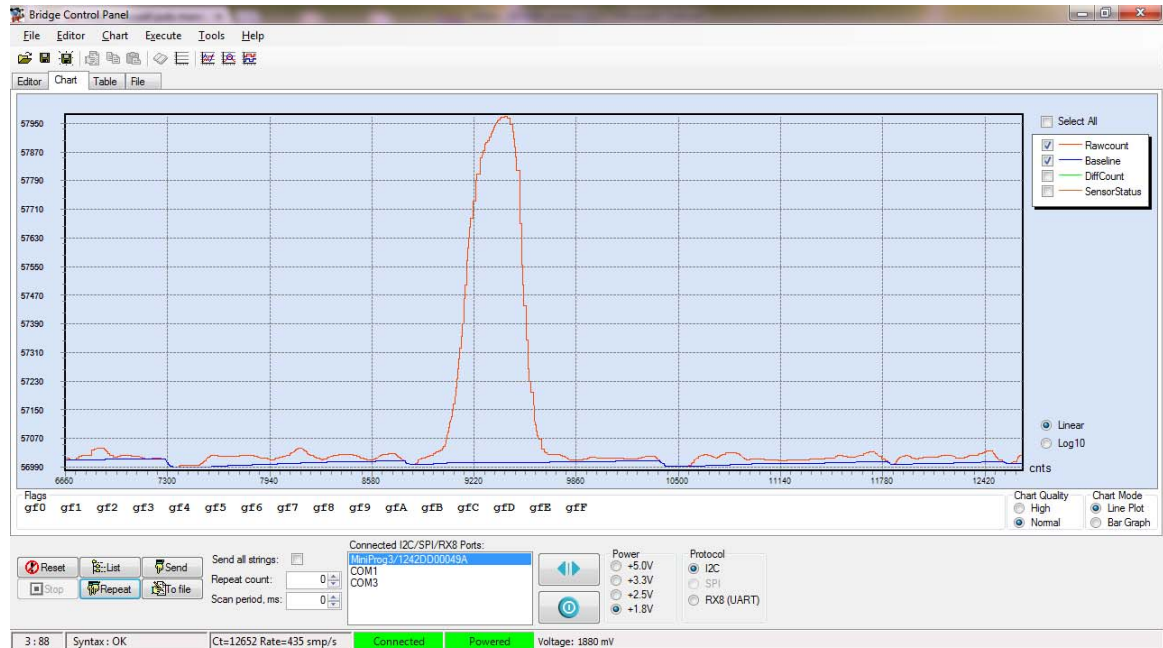
4.   Hardware

4.1   System Block Diagram

Figure 4-1 shows the block diagram of the AEK-CY8C20xx7 QuietZone CapSense Starter Kit. The kit can be powered either through the in-system serial programming (ISSP) header or through the 14-pin edge connector. The AEK-CY8C20xx7 QuietZone CapSense Starter Kit provides flexibility in designing user interface configurations, such as buttons and sliders, and in implementing proximity designs.

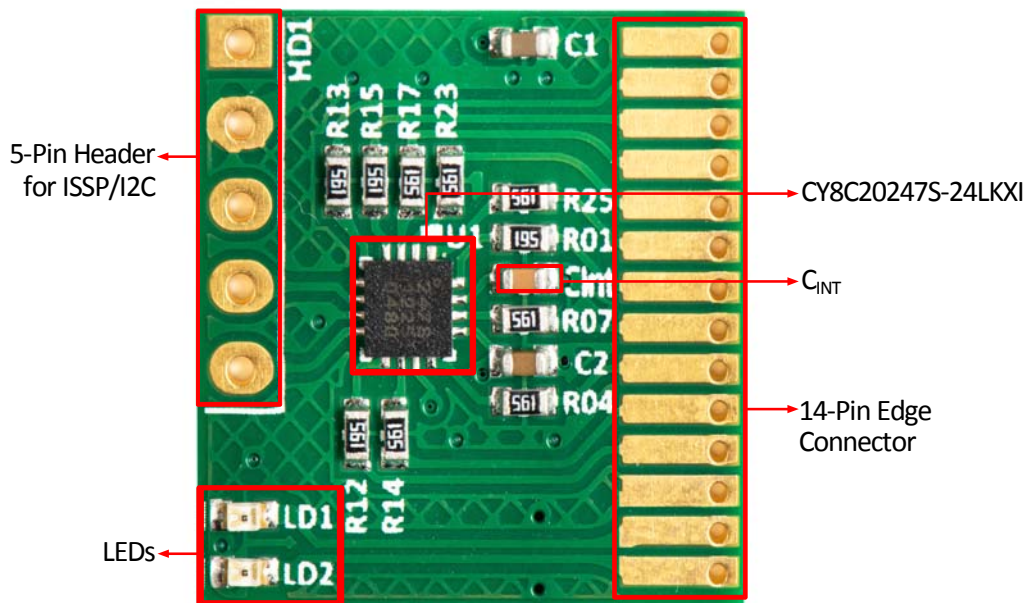Figure 4-1. AEK-CY8C20xx7 QuietZone CapSense Starter Kit Block Diagram
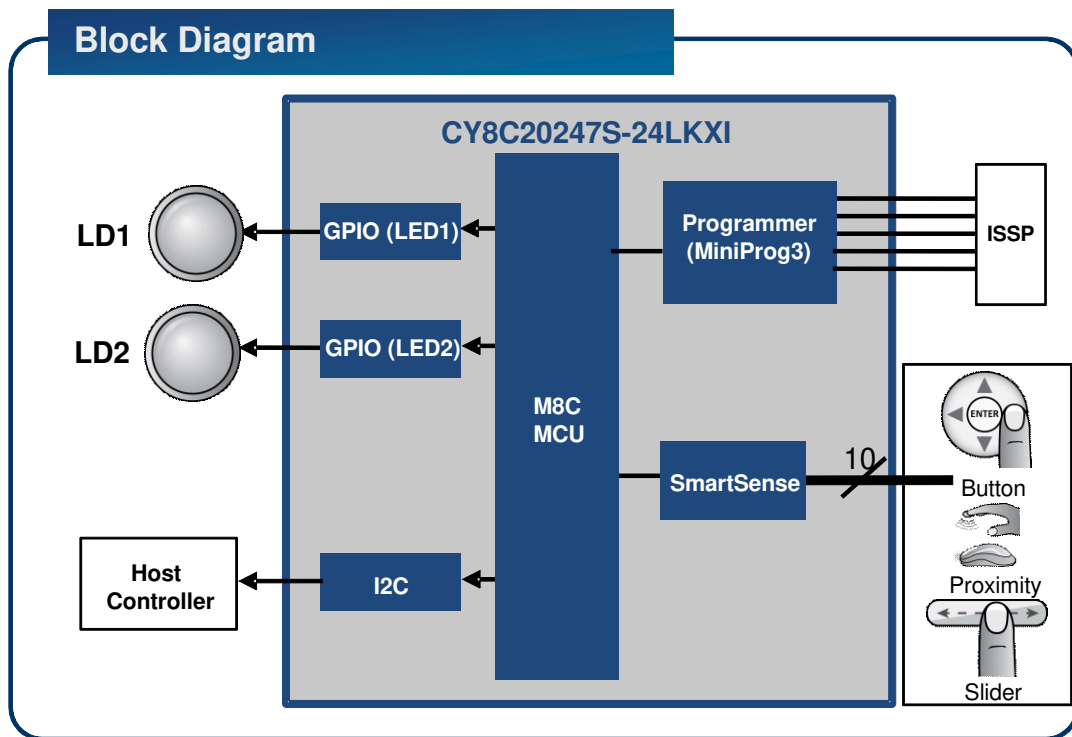
4.2   Functional Description

The AEK-CY8C20xx7 QuietZone CapSense Starter Kit has the following components:

- CY8C20247S-24LKXI
- C_{INT} - integrating/modulating capacitor, also referred to as C_{MOD} in the Cypress documentation
- ISSP/I²C header
- Two onboard LEDs for visual touch feedback
- 14-pin edge connector[1]

Figure 4-2. QuietZone Starter Kit

4.3   Pin Description

Figure 4-3. Pinout for CY8C20247S-24LKXI
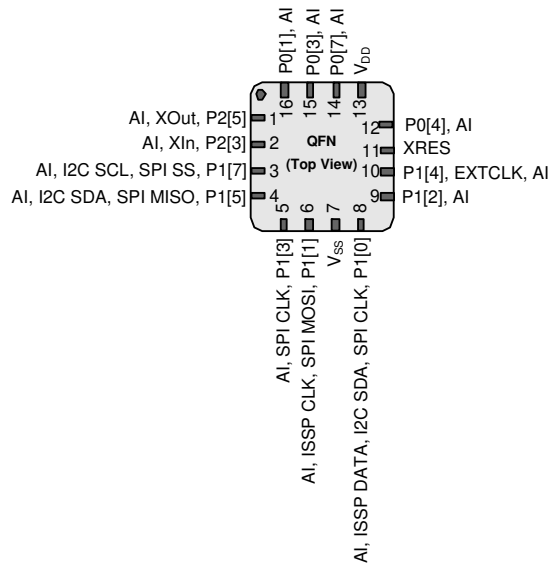
Table 4-1. Pin Definitions for CY8C20247S-24LKXI

| Pin No.	Type		Name	Description
	Digital	Analog		
1	I/O	I	P2[5]	Crystal output (X_{OUT})
2	I/O	I	P2[3]	Crystal input (X_{IN})
3	IOHR	I	P1[7]	I^2C SCL, SPI SS
4	IOHR	I	P1[5]	I^2C SDA, SPI MISO
5	IOHR	I	P1[3]	SPI CLK
6	IOHR	I	P1[1]	ISSP CLK, I^2C SCL, SPI MOSI
7	Power		V_{SS}	Ground connection
8	IOHR	I	P1[0]	ISSP DATA, I^2C SDA, SPI CLK
9	IOHR	I	P1[2]	Driven shield output (optional)
10	IOHR	I	P1[4]	Optional external clock (EXTCLK)
11	Input		XRES	Active high external reset with internal pull-down
12	IOH	I	P0[4]	
13	Power		V_{DD}	Supply voltage
14	IOH	I	P0[7]	
15	IOH	I	P0[3]	Integrating input
16	IOH	I	P0[1]	Integrating input

Legend A = Analog, I = Input, O = Output, OH = 5-mA High-Output Drive, R = Regulated Output.

4.4   14-Pin Edge Connector

The 14-pin edge connector is made up of all the GPIOs, the power (V_{DD}), ground (GND), and a communication interface. Use it to connect with any button or slider sensor hardware. You can connect the two floating LEDs to any output pin. The schematic view of the connector shows the pin mapping.

Figure 4-4. Schematic View of 14-Pin Edge Connector[2]
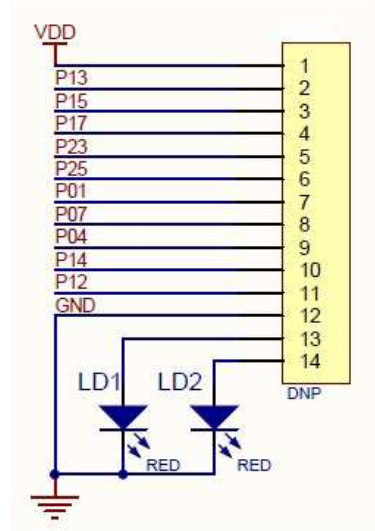
4.5   ISSP/I^{2}C Connector

The ISSP is used to program the PSoC device using the MiniProg3 and USB A to Mini-B cable. Plug the MiniProg3 device into the ISSP header. The ISSP connector is also used to connect the I^{2}C to the USB bridge to allow communication between the PC and the sensor hardware using the Bridge Control Panel.

Figure 4-5. Schematic View of the ISSP Connector

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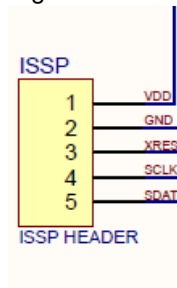
2. The "b" in the labeling indicates the connection to the other end of the 560-ohm resistor. The complete schematics is available in the Appendix on page 31.