CY8CMBR3xxx

CapSense® Design Guide

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Contents

1. Introduction

1.1 Abstract

This guide (*CY8CMBR3xxx CapSense® Design Guide)* shows how to design capacitive touch-sensing applications with the CY8CMBR3xxx CapSense controller family. The CY8CMBR3xxx CapSense controller family offers unprecedented signal-to-noise ratio, best-in-class waterproofing, and a wide variety of sensors such as buttons, sliders, and proximity sensors. This guide explains the CY8CMBR3xxx CapSense design flow, design tools, design considerations, and performance tuning.

1.2 Introduction

Capacitive touch sensors are user-interface devices that use the capacitance of the human body to detect the presence of a finger on, or near, a sensor. Capacitive sensors are aesthetically superior, easy-to-use, and have long lifetimes. Cypress CapSense solutions bring elegant, reliable, and easy-to-use capacitive touch-sensing functionality to your product. Cypress CapSense solutions have replaced more than four billion mechanical buttons.

The CY8CMBR3xxx CapSense Express™ controllers enable advanced, yet easy-to-implement, user interface solutions using capacitive touch sensing. This register-configurable family, which supports up to 16 capacitive sensing inputs, eliminates time-consuming firmware development and tuning process from design cycles. These controllers are ideal for implementing capacitive buttons, sliders, and proximity sensing solutions with minimal development-cycle time. The CY8CMBR3xxx controller enables the development of robust water-tolerant CapSense applications by eliminating false touches due to mist, moisture, water droplets, liquids, or streaming water.

The CY8CMBR3xxx CapSense Design Guide explains how to implement capacitive touch sensing functionality using the CY8CMBR3xxx family of CapSense controllers. This guide assumes that you are familiar with Cypress's CapSense technology. If you are new to CapSense technology, refer to the *Getting Started with CapSense* guide to understand its basics.

This design guide helps you understand:

- Features of the CY8CMBR3xxx CapSense controller family
- CapSense technology utilized in the CY8CMBR3xxx family
- Schematic and layout design considerations
- How to configure the CY8CMBR3xxx family
- Performance tuning
- Low-power design considerations

1.3 CY8CMBR3xxx Family Feature Overview

The CY8CMBR3xxx family is a high-performance, low-power CapSense Express™ controller which enables advanced, yet easy-to-implement, user interface solutions using capacitive touch sensing.

The CY8CMBR3xxx family features include:

- Register-configurable CapSense Express Controller
  - Configurable through the I^2C interface
  - No firmware development or device programming required
  - Supports up to 16 capacitive sensing inputs
  - Supports up to eight general purpose outputs (GPOs)
  - GPOs are either linked to CapSense sensors or controlled by the host processor
  - GPOs support direct LED drive
- SmartSense™ Auto-Tuning
  - CapSense algorithm that continuously compensates for system, manufacturing, and environmental changes
  - Automatically configures capacitive button parameters for optimal performance
  - Eliminates the need for manual system tuning
  - Wide parasitic capacitance (C_P) range (5-45 pF)
  - Allows user to set thresholds manually if required
- Advanced features
  - Wake-on-approach
    - Wakes the system from a low-power mode to active mode on a proximity event.
  - Water-tolerance
    - Enables capacitive buttons to work properly in the presence of water droplets, water stream, or mist
  - PWM output on GPO pins
    - User-configurable LED brightness during sensor ON/OFF state
  - Flanking Sensor Suppression (FSS)
    - Distinguishes between touches from closely spaced buttons
  - Firmware Filters to improve SNR
  - Buzzer signal output for audible touch feedback
  - Analog voltage output using external resistor bridge
  - Host interrupt output to alert the host of any change in sensor status
  - System-diagnostics data through I^2C interface
    - Simplifies production line testing and system debug
- Noise immunity
  - Pseudo-Random Sequence (PRS) clock source to minimize electromagnetic interference
  - Electro Magnetic Compatibility (EMC) feature provides superior noise immunity against external radiated and conducted noise
- System diagnostics that can detect:
  - Sensor shorted to VDD and Ground
  - Sensor-to-Sensor shorts

  - Sensor shorted to Shield
  - Improper value of modulating capacitor (C_{MOD})
  - Parasitic capacitance (CP) of the sensors that is out of range
- I^{2}C interface
  - Supports up to 400-kHz speed
  - Wake-on-hardware address match
  - No clock stretching
- Wide operating voltage range
  - 1.71 to 5.5 V operation
- Low power consumption
  - Supports different modes of operation to reduce the power consumption of the device
  - Average current consumption of 22 µA per sensor at 120-ms scan period
  - Deep sleep current with I^{2}C ON : 2.5 µA
- Industrial temperature range: –40 °C to +85 °C
- Package options
  - 8-pin SOIC (150 mil)
  - 16-pin SOIC (150 mil)
  - 16-pin QFN (3 × 3 × 0.6 mm)
  - 24-pin QFN (4 × 4 × 0.6 mm)

1.4 CY8CMBR3xxx Family Feature Comparison

Table 1-1 compares the features supported by different controllers of the CY8CMBR3xxx family. These controllers are differentiated based on the number of sensors and features supported. Use this table to select the appropriate device that meets your design requirements.

Table 1-1. Comparison of CY8CMBR3xxx Controllers

#	Feature	MBR3116	MBR3106S	MBR3110	MBR3108	MBR3102	MBR3002
1	Maximum number of buttons	16	11	10	8	2	2
2	Maximum number of slider segments	✗	10	✗	✗	✗	✗
3	Maximum number of proximity sensors	2	2	2	2	2	✗
4	Shield electrode	✓	✓	✓	✓	✓	✗
5	Guard Sensor	✓	✗	✓	✓	✗	✗
5	Wake-on-approach	✓	✓	✓	✓	✓	✗
6	Water tolerance	✓	✗	✓	✓	✓	✗
7	Maximum number of GPOs/LED drive outputs	8	0	5	4	1	2
8	LED brightness control	✓	✗	✓	✓	✓	✗
9	I^{2}C Interface	✓	✓	✓	✓	✓	✗
10	Buzzer drive output	✓	✓	✓	✓	✗	✗
11	Host interrupt output	✓	✓	✓	✓	✗	✗
12	FSS	✓	✓	✓	✓	✓	✗
13	Median & IIR filter	✓	✓	✓	✓	✓	✓
14	Advanced-Low-Pass Filter	✓	✗	✓	✓	✓	✗
15	Electro Magnetic Compatibility (EMC)	✓	✓	✓	✓	✓	✓
16	Sensitivity control	✓	✓	✓	✓	✓	✗
17	Auto finger threshold	✓	✓	✓	✓	✓	✓
18	Flexible finger threshold	✓	✓	✓	✓	✓	✗
19	LED ON time	✓	✗	✓	✓	✓	✗
20	Toggle Mode	✓	✗	✓	✓	✓	✗
21	System diagnostics	✓	✓	✓	✓	✓	✓
22	Sensor auto-reset	✓	✓	✓	✓	✓	✓

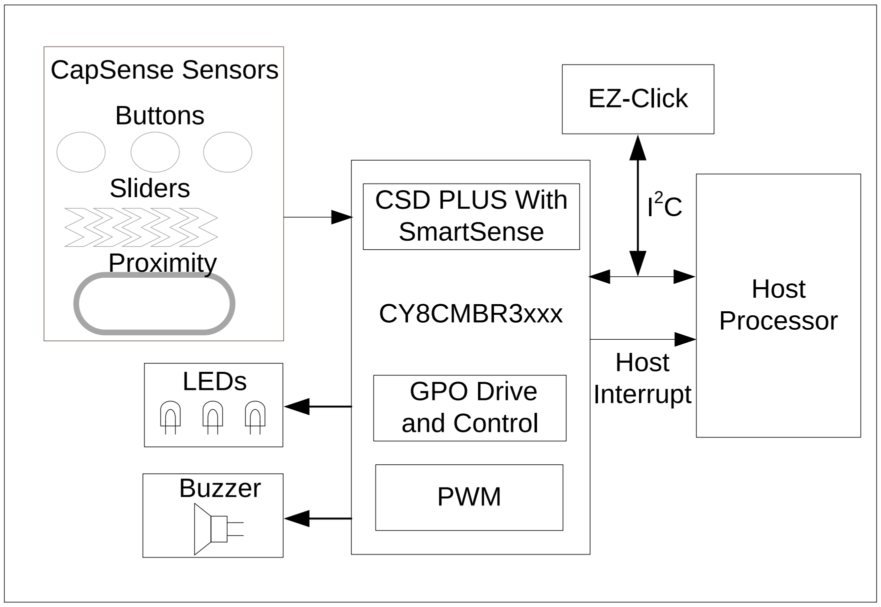
Notes:

- The CY8CMBR3102 controller does not support GUARD sensor and hence it provides water tolerance only for water droplets and not for water flow.
- The sensor auto-reset for CY8CMBR3002 is fixed to 20 s and is not configurable.

1.5 CY8CMBR3xxx CapSense System Overview

Figure 1-1 shows the typical system-level block diagram of a CapSense application with the CY8CMBR3xxx CapSense controller. The CY8CMBR3xxx controller acts as a slave device that detects finger touches on the user interface panel, and reports the touch status to the host processor. The CY8CMBR3xxx controller sends an interrupt pulse to the host processor whenever the sensor status changes, so that the host can read the sensor status through the I²C interface. The CY8CMBR3xxx controller provides touch feedback by driving GPOs and dedicated buzzer output. EZ-Click™ tool is used to configure and debug the CY8CMBR3xxx controller using the I²C interface.

Figure 1-1. Block Diagram of a CapSense System With CY8CMBR3xxx Controller



1.6 CapSense Design Flow

Figure 1-2 shows the typical flow of a product design cycle with capacitive sensing using CY8CMBR3xxx controller. Table 1-2 lists the supporting documentation and eco-system for designing CapSense application with the CY8CMBR3xxx controller.

Figure 1-2. Typical CapSense Product Design Flow

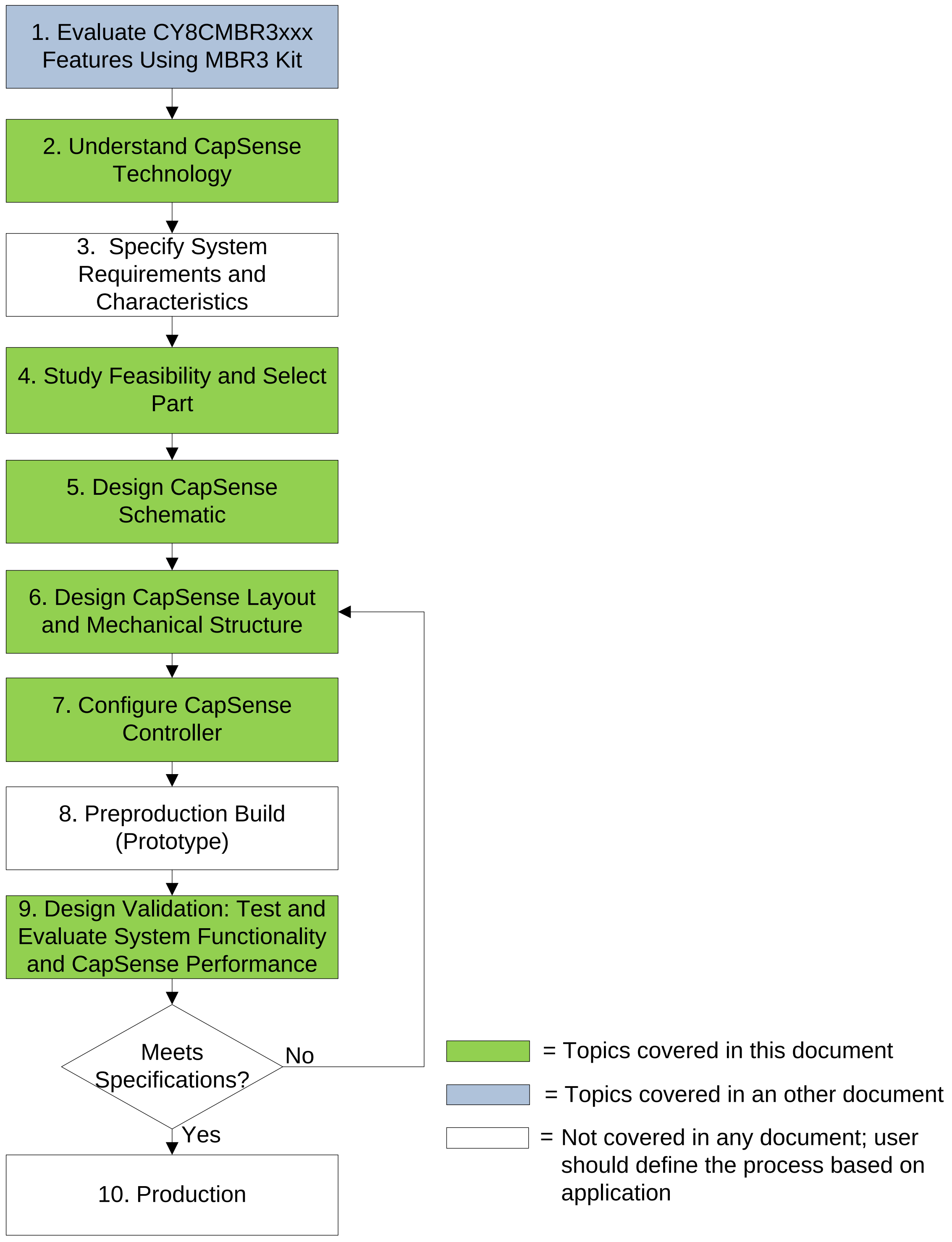

1. Evaluate CY8CMBR3xxx Features Using MBR3 Kit
2. Understand CapSense Technology
3. Specify System Requirements and Characteristics
4. Study Feasibility and Select Part
5. Design CapSense Schematic
6. Design CapSense Layout and Mechanical Structure
7. Configure CapSense Controller
8. Preproduction Build (Prototype)
9. Design Validation: Test and Evaluate System Functionality and CapSense Performance
Meets Specifications?
No
Yes
10. Production
= Topics covered in this document
= Topics covered in an other document
= Not covered in any document; user should define the process based on application

Table 1-2. Supporting Documentation and Ecosystem

Steps in the Flowchart	Supporting Cypress Documentation	
	Name	Chapter
1. Evaluate Features of CY8CMBR3xxx Using MBR3 Kit	CY3280-MBR3 Evaluation Kit User Guide	NA
2. Understand CapSense Technology	Getting Started With CapSense CY8CMBR3xxx CapSense Design Guide (This document)	Chapter 2
3. Specify System Requirements and Characteristics	Not covered in any document; user should define the process based on application	NA
4. Feasibility Study: Part Selection	CY8CMBR3xxx CapSense Design Guide (This document) CY8CMBR3xxx Datasheet	Chapter 1
5. Design CapSense Schematic	CY8CMBR3xxx CapSense Design Guide (This document)	Chapter 3
6. Design CapSense Layout and Mechanical Structure	CY8CMBR3xxx CapSense Design Guide (This document)	Chapter 4
7. Configure CapSense Controller	CY8CMBR3xxx CapSense Design Guide (This document)	Chapter 5
8. Preproduction Build (Prototype)	Not covered in any document; user should define the process based on the application	NA
9. Design Validation	CY8CMBR3xxx CapSense Design Guide (This document)	Chapter 6
10. Production	Not covered in any document; user should define the process based on the application	NA

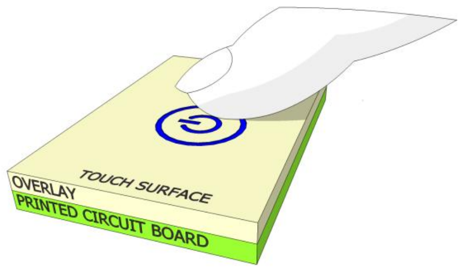
2. CapSense Technology

The capacitive touch sensing technology enables measurement of the change in the capacitance between a plate (the sensor) and its environment to detect the presence of a finger on or near a touch surface.

2.1 CapSense Fundamentals

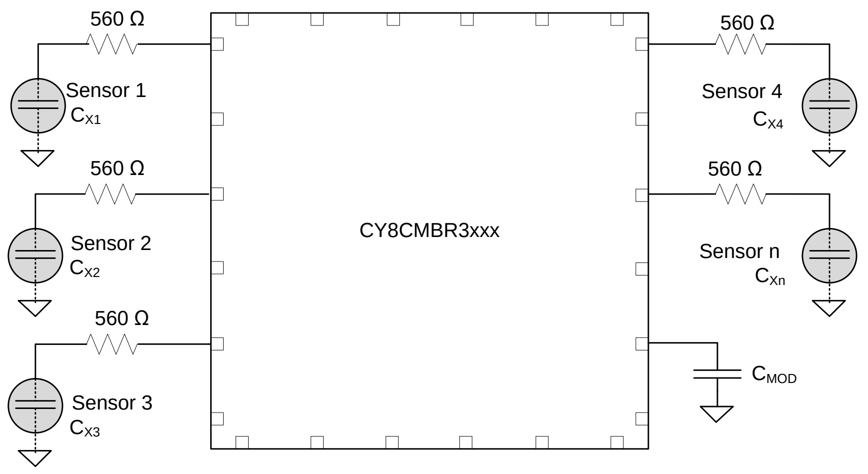
A typical CapSense sensor consists of a copper pad etched on the surface of a Printed Circuit Board (PCB). A nonconductive overlay serves as the touch surface for the sensor, as Figure 2-1 shows.

Figure 2-1. Capacitive Touch Sensor



PCB traces and vias connect the sensor pads to the CapSense input pins of the CY8CMBR3xxx controller. As Figure 2-2 shows, the total amount of capacitance on each of the sensor pins is modeled as the equivalent lumped capacitor with values of C_{X1}, C_{X2}, through C_{Xn}. The CapSense circuitry within the CY8CMBR3xxx controller converts these capacitance values into equivalent digital counts. These digital counts are then processed by the controller to detect touches.

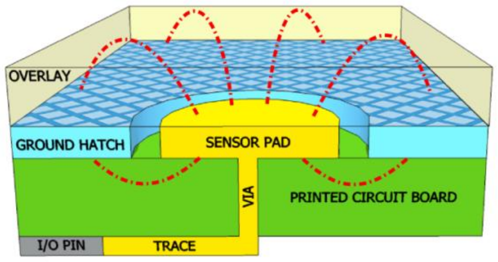
Figure 2-2. CapSense Implementation in the CY8CMBR3xxx Device



Note: The CY8CMBR3xxx controller requires an external capacitor C_{MOD}, which is connected between the CMOD pin and ground.

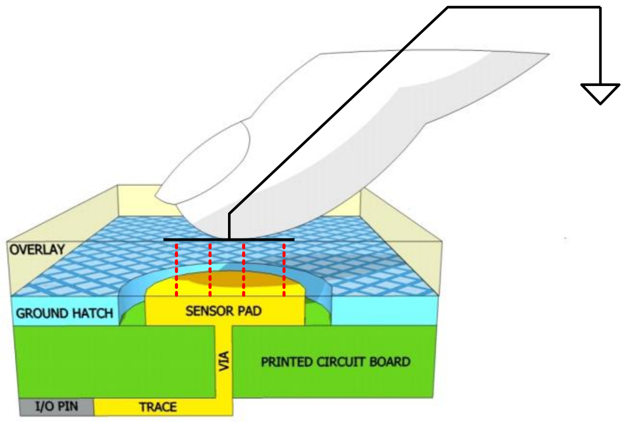
The capacitance of the sensor in the absence of a touch is called the *parasitic capacitance*, C_P. Parasitic capacitance results from the electric field between the sensor (including the sensor pad, traces, and vias) and other conductors in the system such as the ground planes, traces, any metal in the product's chassis or enclosure, etc. The sensor pin and internal capacitances of CY8CMBR3xxx controller also contribute to the parasitic capacitance. However, these internal capacitances are typically very small compared to the sensor capacitance. Figure 2-3 shows how a CY8CMBR3xxx sensor pin is connected to a sensor pad with traces and vias. Typically, a ground hatch surrounds the sensor pad to isolate it from other sensors and traces. Although this diagram shows some field lines around the sensor pad, the actual electric field distribution is complex.

Figure 2-3. Parasitic Capacitance



When a finger is present on the overlay, the conductive nature and large mass of the human body forms a grounded, conductive plane parallel to the sensor pad, as Figure 2-4 shows.

Figure 2-4. Section of Typical CapSense PCB With the Sensor Being Activated by a Finger



This arrangement forms a parallel plate capacitor. The capacitance between the sensor pad and the finger is:

$$C_F = \frac{\varepsilon_0\, \varepsilon_r\, A}{d} \qquad \text{Equation 1}$$

Where: ε_0 = Free space permittivity

ε_r = Dielectric constant (relative permittivity) of the overlay

A = Area of finger and sensor pad overlap

d = Overlay thickness

C_F is known as the finger capacitance. The parasitic capacitance C_P and finger capacitance C_F are parallel to each other because both represent the capacitances between the sensor pin and ground. Therefore, the total capacitance C_X of the sensor, when the finger is present on the sensor, is the sum of C_P and C_F.

$$C_X = C_P + C_F \qquad \text{Equation 2}$$

In the absence of touch, C_X is equal to C_P.

The CY8CMBR3xxx controller converts the capacitance C_X into equivalent digital counts called *raw counts*. Because a finger touch increases the total capacitance of the sensor pin, an increase in the raw counts indicates a finger touch. As the parasitic capacitance C_P increases, the ratio of C_F to C_P decreases – the per unit change in capacitance corresponding to a finger touch decreases. Therefore, as C_P increases, touch detection becomes more difficult.

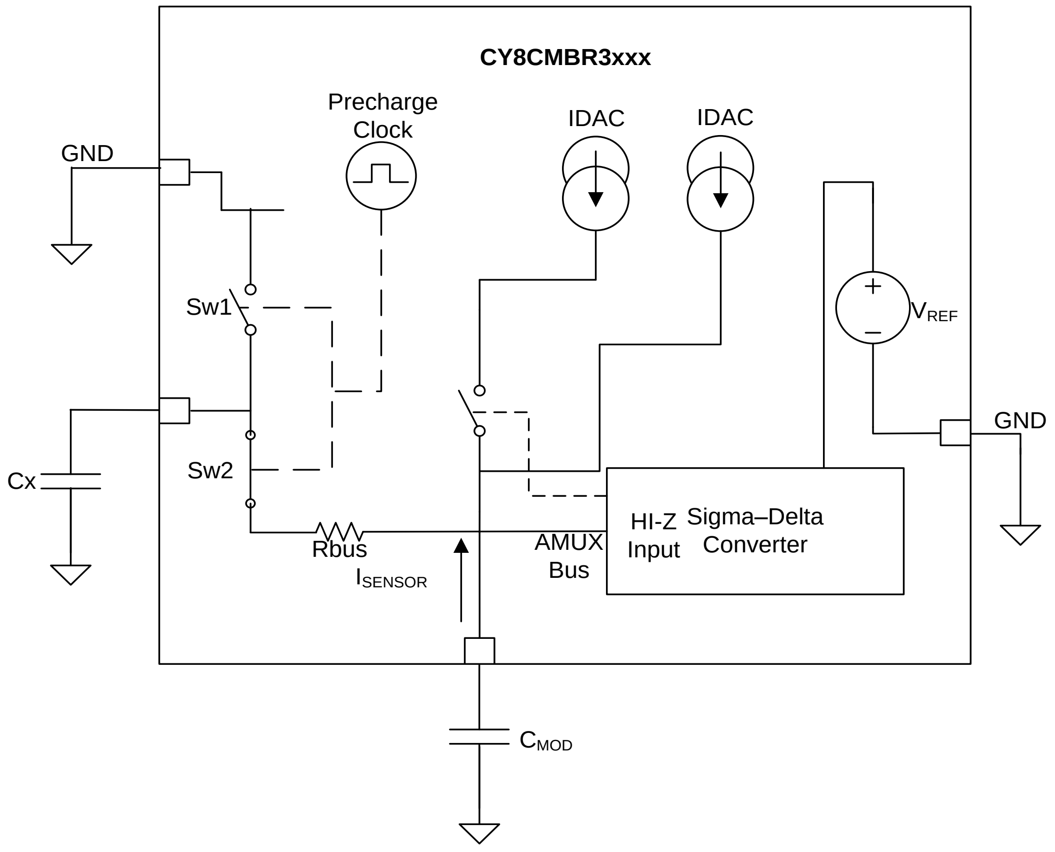
In general, C_P is an order of magnitude greater than C_F. C_P usually ranges from 10-20 pF, but in extreme cases it can be as high as 45 pF. C_F usually ranges from 100-400 fF.

2.2 Capacitive Touch-Sensing Method in CY8CMBR3xxx

The CY8CMBR3xxx controller uses a capacitive touch-sensing method - CapSense Sigma Delta PLUS (CSD PLUS) - to convert the changes in capacitance to digital counts. The CSD PLUS touch-sensing method delivers a signal-to-noise ratio (SNR) that ensures touch accuracy even in extremely noisy environments.

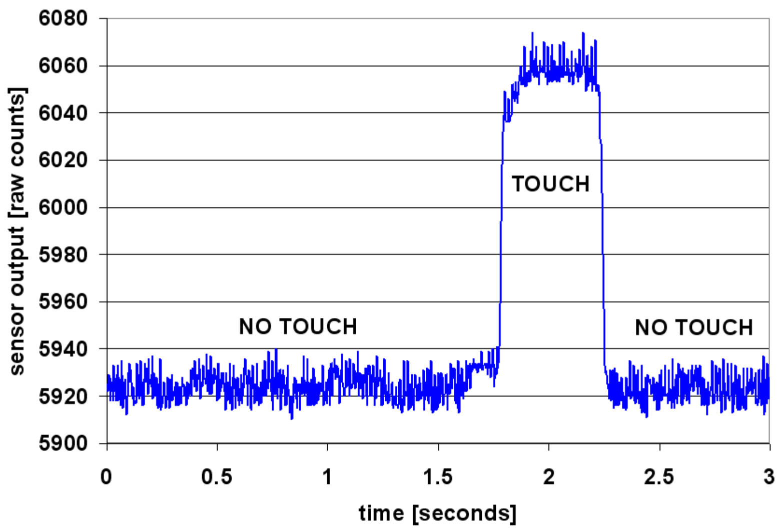
The CSD PLUS CapSense sensing method in the CY8CMBR3xxx device incorporates C_X into a switched capacitor circuit, as Figure 2-5 shows. The sensor (C_X) is alternatively connected to GND and the Analog MUX (AMUX) bus by the non-overlapping switches Sw1 and Sw2. Sw1 and Sw2 are driven by the Precharge Clock to bleed a current (I_{SENSOR}) from the AMUX bus. The magnitude of I_{SENSOR} is directly proportional to the magnitude of C_X. The sigma-delta converter samples the AMUX bus voltage and generates a modulating bit stream that controls the constant current source, IDAC. The IDAC charges AMUX such that the average AMUX bus voltage is maintained at V_{REF}. The sensor bleeds off the current I_{SENSOR} from the modulating capacitor (C_{MOD}), which, in combination with Rbus, forms a low-pass filter that attenuates precharge-switching transients at the sigma-delta converter input.

Figure 2-5. CSD PLUS Block Diagram



In order to maintain the AMUX bus voltage at V_{REF}, the sigma-delta converter matches IDAC output current to I_{SENSOR} by controlling the bit stream duty cycle. The sigma-delta converter stores the bit stream over the duration of a sensor scan, and the accumulated result is a digital raw count output, which is directly proportional to C_X. This raw count is interpreted by high-level algorithms to resolve the sensor state. Figure 2-6 plots the CSD PLUS raw counts from a number of consecutive scans during which the sensor is touched and then released by a finger. As explained in CapSense Fundamentals, the finger touch causes C_X to increase by C_F, which in turn causes raw counts to increase proportionally. By comparing the shift in the raw count level from the steady state to a predetermined threshold, the high-level algorithms can determine whether the sensor is in an ON (Touch) or OFF (No Touch) state. To learn more about raw counts, finger threshold, and signal-to-noise ratio (SNR), refer to the *Getting Started with CapSense* guide.

Figure 2-6. Raw Counts during Finger Touch



2.3 CapSense Tuning

Optimal CapSense system performance depends on the board layout, sensor dimensions, overlay material, and application requirements. These factors are discussed in CapSense Layout Guidelines. In addition to these factors, CSD PLUS sensing method requires a few hardware and software parameters to be set for robust operation. The process of setting the optimum value for these parameters is called manual tuning. Manual tuning is a laborious and time consuming process. Cypress's SmartSense Auto-Tuning algorithm eliminates the manual tuning process by automatically setting all of the hardware and software parameters.

2.4 SmartSense Auto-Tuning

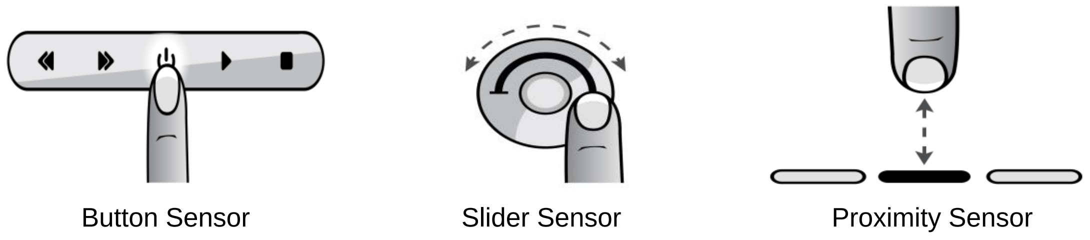
Tuning the touch-sensing user interface is critical for proper system operation and a pleasant user experience. The typical design flow involves tuning the sensor interface in the initial design phase, during system integration, and finally production fine-tuning before the production ramp. Tuning is an iterative process and can be time-consuming.

SmartSense Auto-Tuning is a CapSense algorithm that automatically configures capacitive button parameters for optimum performance. It continuously compensates for system, manufacturing, and environmental changes, and simplifies the user interface development cycle. It is easy to use and reduces design cycle time by eliminating manual tuning during the prototype and manufacturing stages. SmartSense Auto-Tuning tunes each CapSense button automatically at power up and maintains optimum button performance during runtime. SmartSense Auto-Tuning adapts for manufacturing variations in PCBs and overlays. It automatically tunes out noise from various sources such as LCD inverters, AC lines, and switch-mode power supplies. Refer to the *Getting Started with CapSense* guide to understand how the SmartSense algorithm works.

2.5 Sensor Types

CY8CMBR3xxx supports three types of capacitive sensors - buttons, sliders, and proximity sensors, as Figure 2-7 shows.

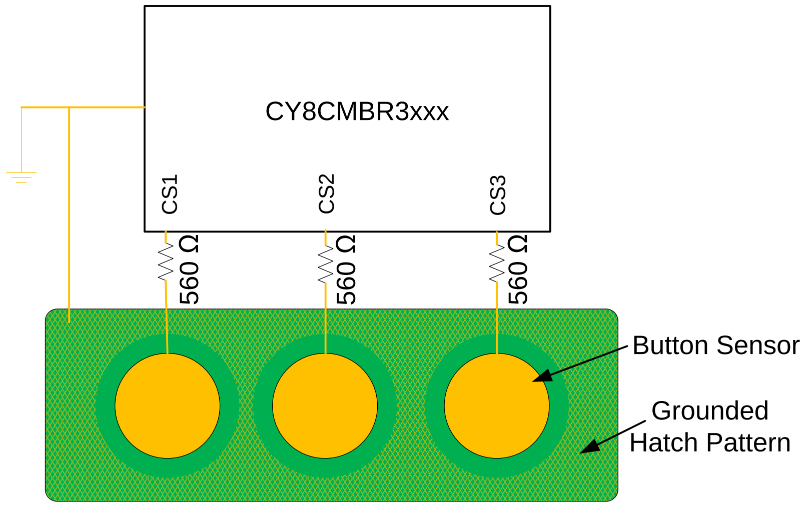
Figure 2-7. Types of Capacitive Sensors Supported in CY8CMBR3xxx



2.5.1 Buttons (Zero-Dimensional)

CapSense buttons replace mechanical buttons in a wide variety of applications such as home appliances, medical devices, lighting controls, and many other products. It is the simplest type of CapSense sensor, consisting of a single sensor. A CapSense button gives one of two possible output states: active (finger is present) or inactive (finger is not present). These two states are also called ON and OFF states respectively. A simple CapSense button consists of a circular copper pad. It connects to a pin marked for CapSense button functionality on the CY8CMBR3xxx controller as shown in Figure 2-8. In CY8CMBR3xxx, a CSx pin indicates that a button sensor can be connected to it. The button is surrounded by grounded copper hatch to isolate it from other buttons and traces. A circular gap separates the button pad and the ground hatch. See the General Layout Guidelines section for layout recommendations.

Figure 2-8. Simple CapSense Buttons



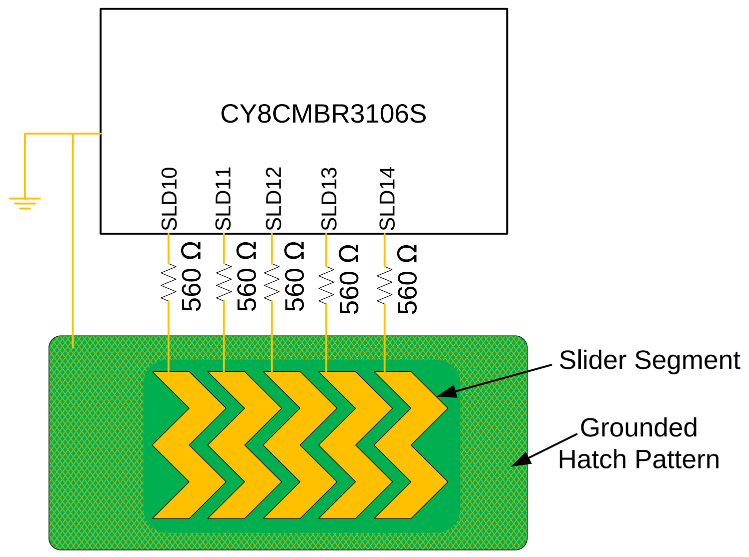
2.5.2 Sliders (One-Dimensional)

Sliders are used when the required output is in the form of a gradual increment or decrement. Examples include lighting control (dimmer), volume control, graphic equalizer, and speed control. A slider consists of a one-dimensional array of capacitive sensors called segments, which are placed adjacent to one another. Touching one segment also results in partial activation of adjacent segments. The firmware processes the raw counts from the touched segment and nearby segments to calculate the position of the geometric center of the finger touch, which is known as the **centroid position**.

The actual resolution of the calculated centroid position is much higher than the number of segments in a slider. For example, a slider with five segments can resolve at least 100 physical finger positions. This high resolution gives smooth transitions of the centroid position as the finger glides across a slider. In a linear slider, the segments are arranged inline, as Figure 2-9 shows.

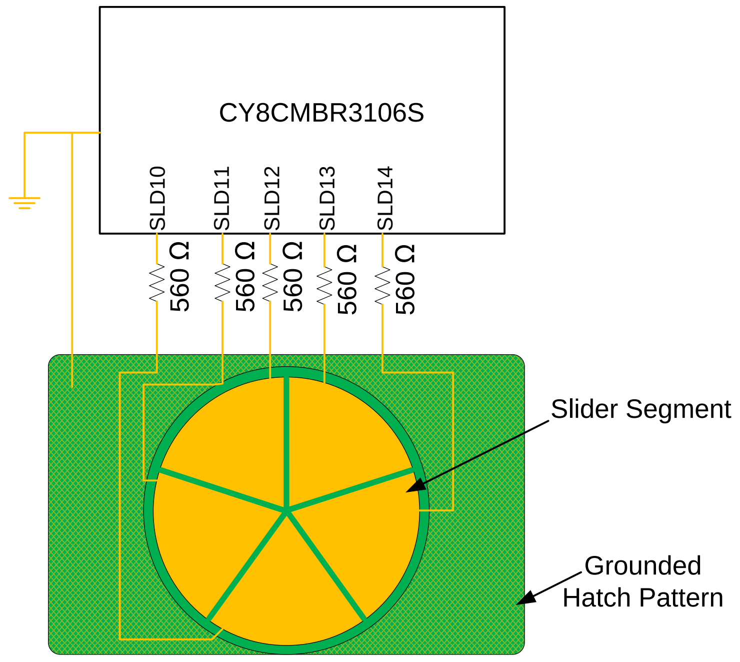
Each slider segment connects to a pin marked for slider functionality on the CY8CMBR3106S controller. In CY8CMBR3106S, a SLDxx pin indicates that a slider segment can be connected to it. A zigzag pattern (double chevron) is recommended for slider segments. This layout ensures that when a segment is touched, the adjacent segments are also partially touched, which helps in the calculation of the centroid position. See the General Layout Guidelines section for layout recommendations.

Figure 2-9. Linear Slider



Radial sliders are similar to linear sliders except that radial sliders are continuous. Figure 2-10 shows a typical radial slider.

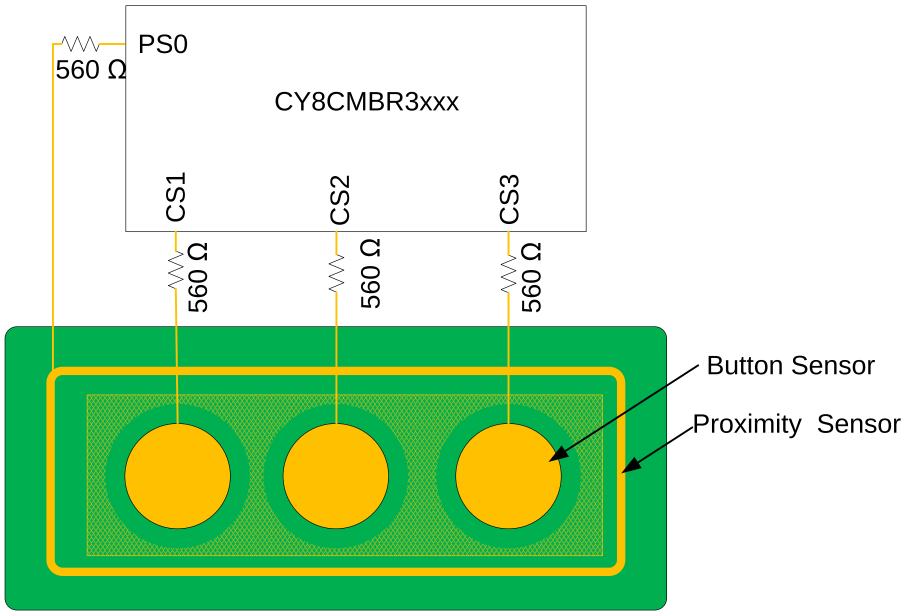
Figure 2-10. Radial Slider



2.5.3 Proximity (Three-Dimensional)

Proximity sensors detect the presence of a hand in the three-dimensional space around the sensor. However, the actual output of the proximity sensor is an ON/OFF state similar to a CapSense button. Proximity sensing can detect a hand at a distance of several centimeters to tens of centimeters depending on the sensor size and construction. Each proximity sensor connects to a pin marked for proximity sensing functionality on the CY8CMBR3xxx controller. In CY8CMBR3xxx controller, a PSx pin indicates that a proximity sensor can be connected to it. Proximity sensing requires electric fields that are projected to much larger distances than buttons and sliders, requiring a large sensor area. The proximity sensor can either be a trace on the PCB or a simple wire loop, as Figure 2-11 shows. See the Layout Guidelines for Proximity Sensor section for more details.

Figure 2-11. Proximity Sensor



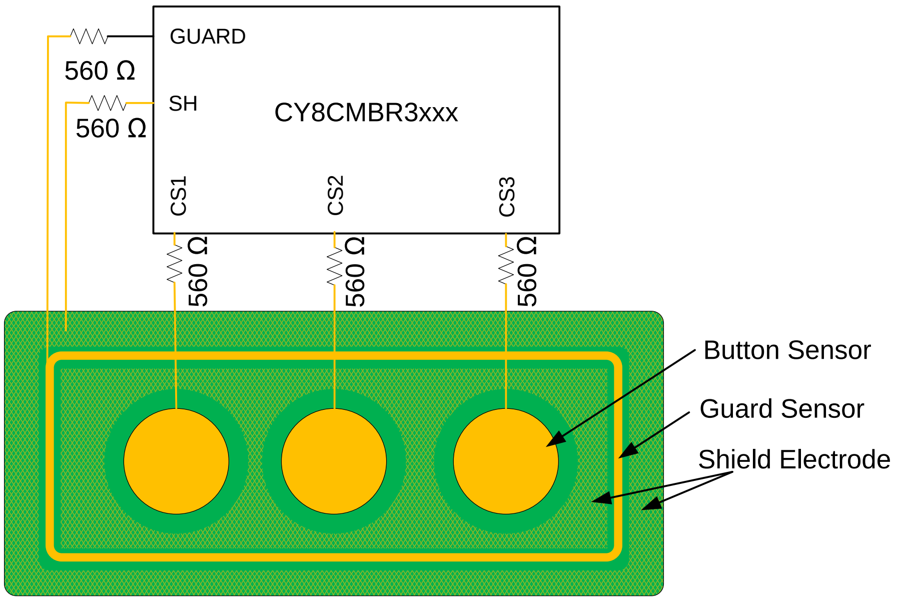
2.6 Water Tolerance

In a CapSense design, false sensing of touch may happen due to the presence of a film of water or droplets on the touch surface. Home Appliances, automotive applications, and industrial applications are examples of systems that must perform in environments that include water, ice, and humidity changes. For such applications, a shield electrode and guard sensor can provide robust touch sensing.

If your application requires tolerance to water droplets and moisture, use a shield electrode in your design. If your application also requires tolerance to water flow on the touch surface, use a guard sensor together with a shield electrode.

Note: Water tolerance is not supported for proximity and slider sensors.

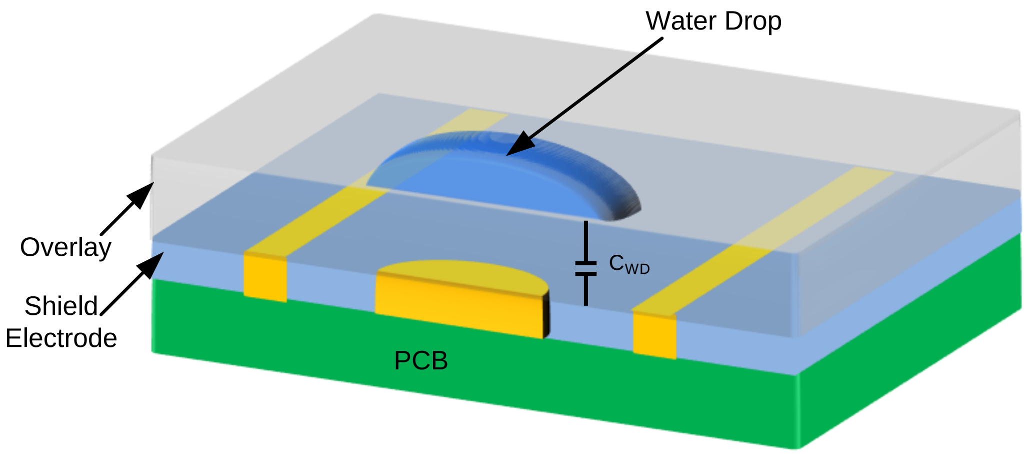
Figure 2-12. Shield Electrode (SH) and Guard Sensor (GUARD) Connected to CY8CMBR3xxx



2.6.1 Shield Electrode

Shield electrodes protect CapSense button sensors from detecting false touches caused by water drops. When water drops are present on the overlay surface, the coupling between the shield electrode and the sensor pad is increased by C_{WD}, as Figure 2-13 shows.

Figure 2-13. Capacitance Measurement with Water Drop



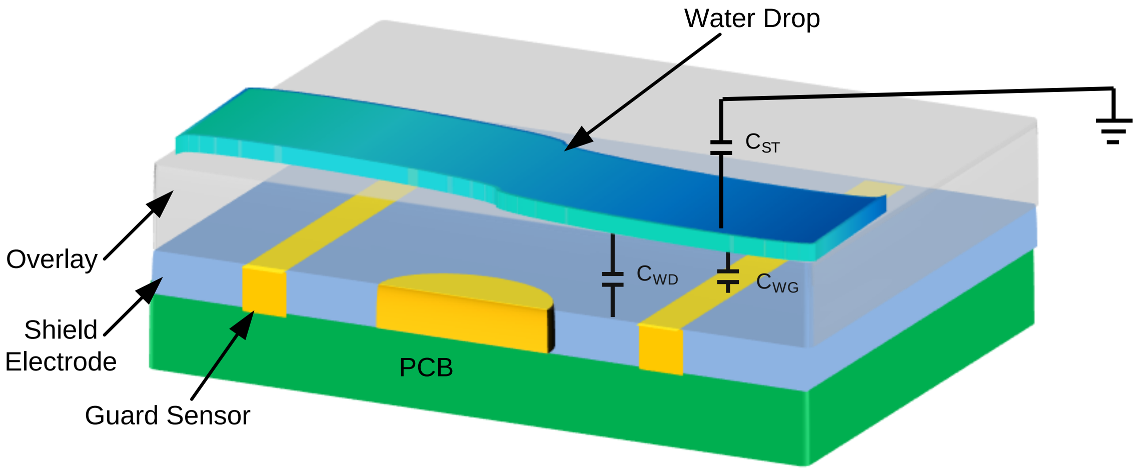
- C_{WD} – Capacitance between the water drop and shield electrode

The purpose of the shield electrode is to set up an electric field around the touch sensors that helps attenuate the effects of water. The shield electrode works by mirroring the voltage of the touch sensor on the shield. Since the shield electrode and sensors are driven with the same signals, the potential difference between them is zero and any capacitance between the sensors and the shield electrode cannot cause a charge transfer. Therefore, any water film or droplets that are present partially on both the sensor and shield area do not change the sensor capacitance, allowing CapSense to work in the presence of water film or droplets.

2.6.2 Guard Sensor

A guard sensor is a copper trace that surrounds all the sensors on the PCB, as Figure 2-12 shows. It is used to detect the presence of streaming water. When a water stream is present on the sensing surface, a large capacitance (C_{ST}) is added to the system, as Figure 2-14 shows. This capacitance may be several times larger than C_{WD}. Because of this, the effect of the shield electrode is completely masked, resulting in the same or even higher raw counts measured by the sensor than a finger touch. In this situation, when the guard sensor detects a water stream, it blocks other sensors from triggering. Therefore, touch cannot be detected when streaming water is present.

Figure 2-14. Capacitance Measurement With Water Stream



- C_{WD} - Capacitance between the water stream and shield electrode
- C_{ST} - Capacitance between the water stream and the system ground
- C_{WG} - Capacitance between the water stream and the guard sensor

To make your design water-tolerant, follow these steps:

1. If your application requires tolerance to water droplets and moisture, choose a CY8CMBR3xxx controller that has shield feature. If your application also requires tolerance to water flow, choose a CY8CMBR3xxx controller that has both shield and guard features. Refer to Table 1-1 to select the controller.

2. Follow the schematic and layout guidelines explained in the Layout Guidelines for Water Tolerance section to construct the shield electrode and guard sensor.

3. Enable shield and guard sensor features in the EZ-Click as explained in the Shield and Guard Sensor configuration section.

4. Tune the guard sensor as explained in the Tuning the Buttons, Sliders, and Guard Sensor section.

3. CapSense Schematic Design

The CY8CMBR3xxx controller supports buttons, sliders, and proximity sensors on dedicated pins. Also, the number of buttons, sliders and proximity sensors supported is fixed in this controller. Selecting the sensor pins is the first step in designing a CapSense application. This chapter provides guidelines on selecting sensor pins for designing a CapSense schematic.

3.1 Schematic Design Considerations

Designing a schematic with CY8CMBR3xxx involves the following steps:

1. Special Output Pin selection
2. Sensor Pin selection
3. GPO Pin selection
4. Power and Ground connections
5. I^{2}C lines connection

This chapter explains how to select the special output, sensor, and GPO pins. Refer to the CY8CMBR3xxx datasheet for information on power, ground, and I^{2}C lines connection.

3.1.1 Selecting the Special Output Pins

The shield electrode, guard sensor, buzzer, and host interrupt pins are called special output pins (SPOs). These features are multiplexed with sensor pins and are supported only on dedicated pins. Therefore, it is important to select these special outputs pins before connecting sensor pins.

For example, consider a CapSense design which requires seven buttons, buzzer output, and the water-tolerance feature. As listed in Table 1-1, the CY8CMBR3116 and CY8CMBR3110 controller fits the design requirement. For illustration purpose, CY8CMBR3110 is selected. The first step in the schematic design is to select the Buzzer (BUZ), Shield (SH), and Guard (GUARD) pins because these pins are multiplexed with the sensor and GPO pins, as Figure 3-1 shows. Refer to the "Pinouts" section in the CY8CMBR3xxx datasheet to know the multiple features supported on the same pin. After the special output pins are selected, select the button sensors CS0, CS1, CS3, CS5, CS6, CS7, and CS8, as Figure 3-2 shows.

Figure 3-1. Multiple Features Supported on a Single Pin

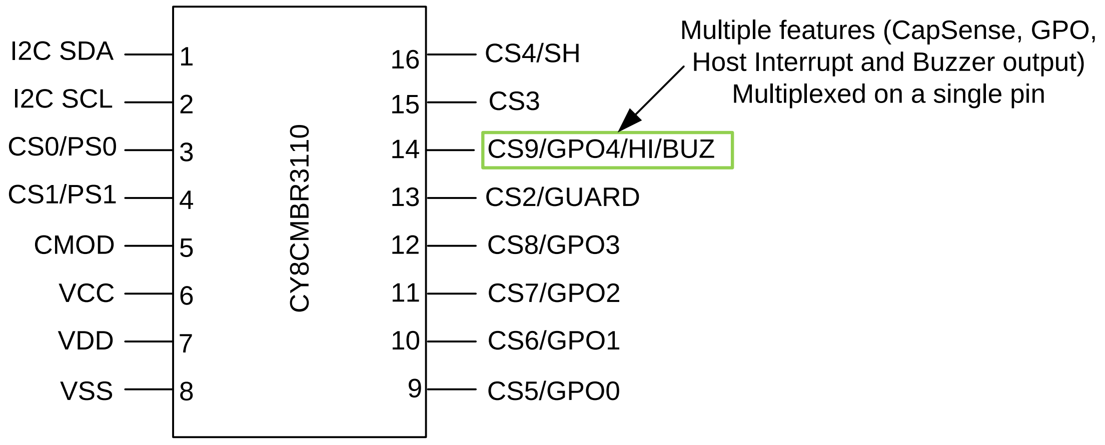
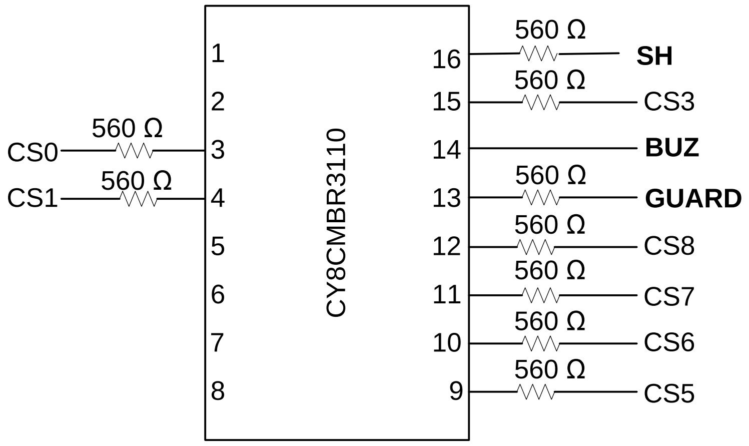


Figure 3-2. Special Output (SPO) Pin Selection



3.1.2 Selecting the Sensor Pin

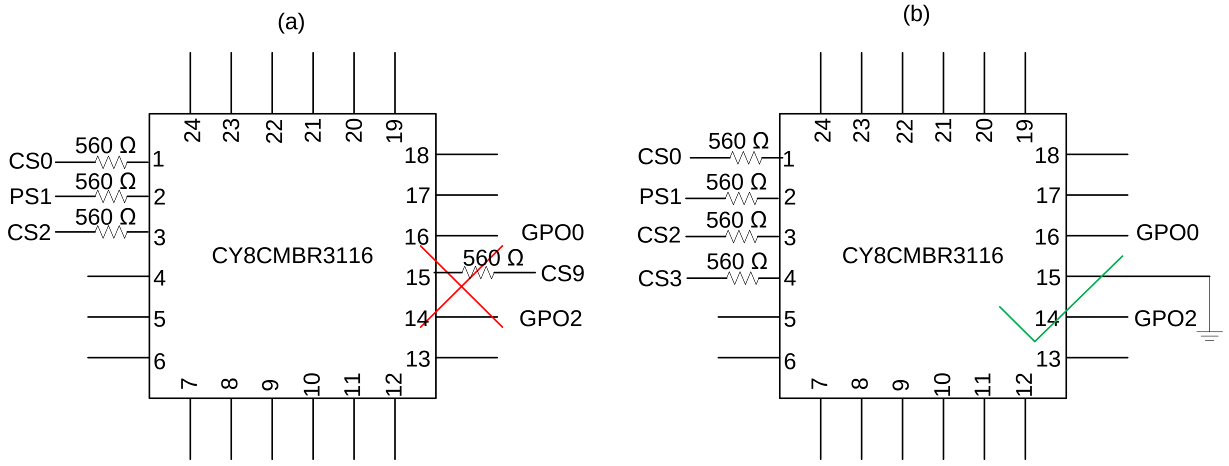
While selecting the sensor pins, do not select the sensor pins (CSx, SLDx, PSx, or GUARD) that are next to or in between GPO pins. Selecting a sensor pin next to a GPO pin might result in cross-talk. If the sensor trace and GPO trace runs parallel to each other, then the GPO switching may cause the sensor next to GPO pin to false trigger. Refer to "PCB Layout Guidelines" section in Getting Started with CapSense guide for guidelines to avoid crosstalk.

For example, Figure 3-3 (a) shows a schematic in which the sensor CS9 is in between GPO0 and GPO2 pin. In this case, if the CS9 trace runs parallel to the GPO0 or GPO2 trace, switching of GPO0 or GPO2 might cause the sensor CS9 to false trigger. This false trigger can be avoided by choosing a sensor pin CS3 which is not next to a GPO pin as shown in Figure 3-3 (b) or by ensuring that the sensor trace and GPO trace do not run in parallel,.

If your design requires a proximity sensor, select the proximity sensor pins (PSx) before selecting button (CSx) pins because, proximity sensors are supported only on two pins.

To increase noise immunity, connect a 560 Ω series resistor to the sensor pins. If any CapSense pin is not used, it is recommended to configure it as sensor pin and connect it to ground. Refer to the Sensor Configuration section for details on how to configure a pin as CapSense input.

Figure 3-3. Sensor Pin Selection Guidelines



3.1.3 Selecting the Slider Pins

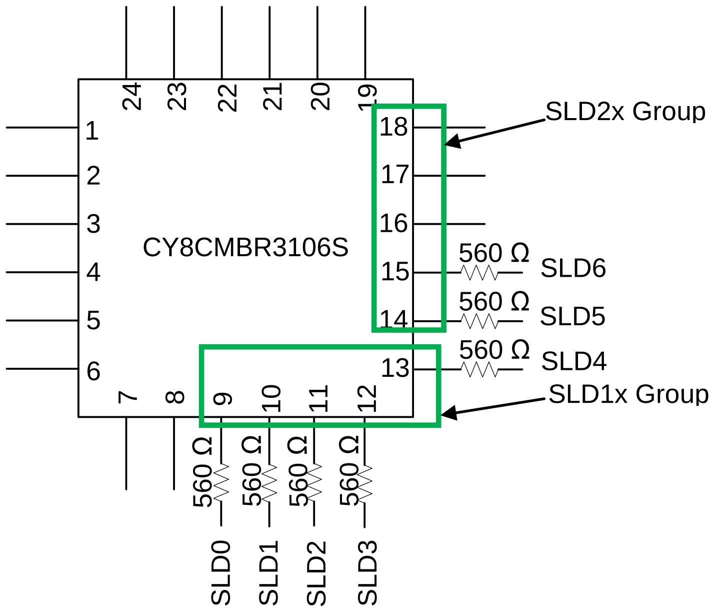
To select the slider pins, refer to Table 3-1.

Table 3-1. Slider Pin Selection Guidelines

Number of Segments	Recommendation
Less than or equal to five	Select the pins from the SLD1x group. SLD10 should be the first slider segment and SLD14 should be the fifth segment.
More than five	Select all the five pins from the SLD1x group for first five slider segments and then select the pins from the SLD2x group for the remaining segments. SLD10 should be the first segment of the slider, SLD20 should be the sixth segment and SLD24 should be the tenth segment.

Figure 3-4 shows an example of a schematic designed for a slider with seven segments. In this schematic, the slider segments SLD0 to SLD4 use the pins from SLD1x group of the controller and the SLD5 and SLD6 segments use the pins from SLD2x group. Remaining pins in the SLD2x group (SLD22, SLD23, and SLD24) can be configured as buttons. If unused, they should be configured as buttons and connected to ground.

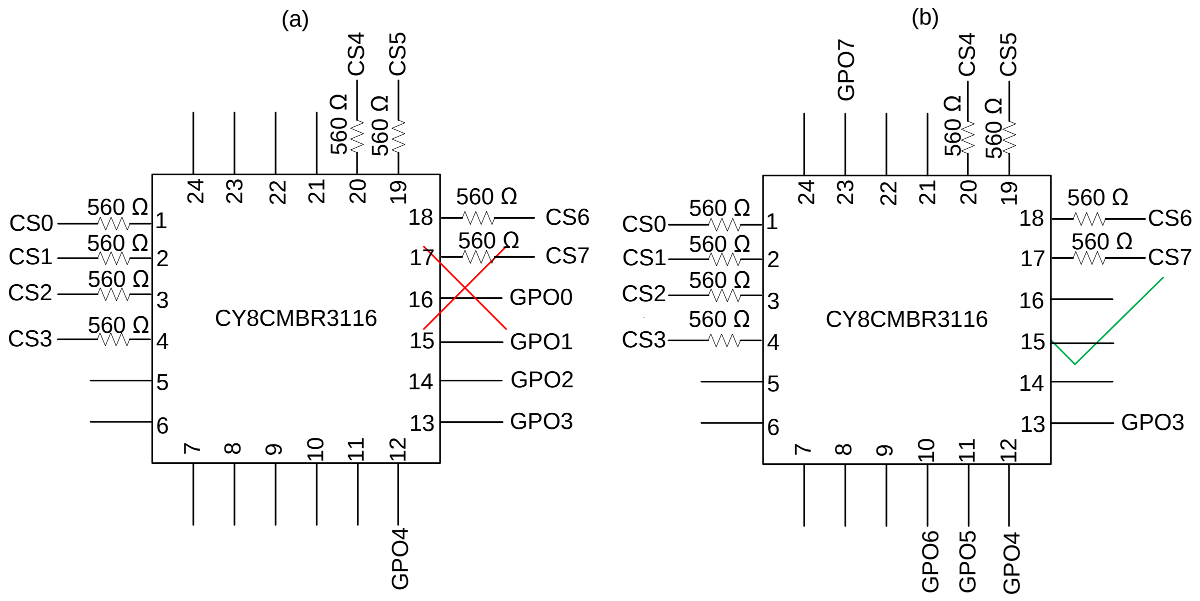
Figure 3-4. Slider Pins Selection



3.1.4 Selecting the GPOs

If the GPOs are controlled by the host controller, any available GPOs can be used to provide touch feedback. It is recommended to select GPOs in the order GPO7 to GPO0. For example, if your design requires eight buttons and five GPOs, select CS0-CS7 for buttons and GPO7-GPO3 for GPOs. This avoids selecting a sensor pin which is next to a GPO pin, as Figure 3-5 shows.

Figure 3-5. Selecting GPO Pins When GPO Host Control Is Enabled



If GPO Host Control is disabled, then each sensor from CS0-CS7 will be mapped to GPO0 to GPO7 respectively. In this case, select the GPOs corresponding to the selected sensor. For example, when GPO host control is disabled and CS0, CS1, and CS2 are selected as buttons, select GPO0, GPO1, and GPO2 as GPO pins to drive LEDs.

The CY8CMBR3xxx controller supports both sourcing and sinking configuration for driving LEDs on GPO pins. Since the sinking capability of GPO is much higher than the sourcing capability, it is recommended to connect the LED in sinking configuration. Refer to DC I/O port specifications in the CY8CMBR3xxx datasheet for maximum sourcing and sinking current limits.

To limit the current, add series resistor of appropriate value depending on the supply voltage. If your design requires a sinking current of more than the maximum limit, connect an external transistor to GPO pin and configure the GPO in strong drive mode using EZ-Click.

3.2 Schematic Checklist

Use the checklist in Table 3-2 to verify your schematic design.

Table 3-2. Schematic Design Checklist

No.	Category	Recommendations/Remarks
1.	Decoupling capacitor on the VDD[1] pin	Connect a 1-µF and 0.1-µF capacitor in parallel
2.	Decoupling capacitor on the VCC[2] pin	Connect a 0.1 µF capacitor if VDD > 1.8 V If VDD is 1.71 V to 1.89 V, short this pin to VDD
3.	Decoupling capacitor on the VDDIO[3] pin	Connect a 1 µF and 0.1 µF capacitor in parallel
3.	C_{MOD}	Connect a 2.2 nF, 5 V, X7R or NPO capacitor
4.	Series resistor on CSx, PSx, SLDx, GUARD, and SH pins	Connect a 560-Ω resistor in series with the pin
5.	Series resistor on I^2C lines	Connect a 330-Ω resistor in series with the SDA[4] and SCL[5] lines
6.	Pull-up on I^2C lines	Select an appropriate value depending on the I^2C interface voltage
7.	Pull-up on the HI line	Select an appropriate value depending on the interface voltage
8.	Unused CapSense pins[6] (CSx, PSx, SLDx, and GUARD)	Configure as button sensor and connect them to ground[7]

3.3 Sample Schematics

3.3.1 Touch Buttons in Mobile Phones

Touch buttons are used in mobile phones for quick access to various applications. A typical mobile phone has up to four touch buttons and requires LED backlighting.

The schematic shown in Figure 3-6 is an example of how to implement touch buttons in mobile phones.

In Figure 3-6, the CY8CMBR3108 controller is configured in the following manner:

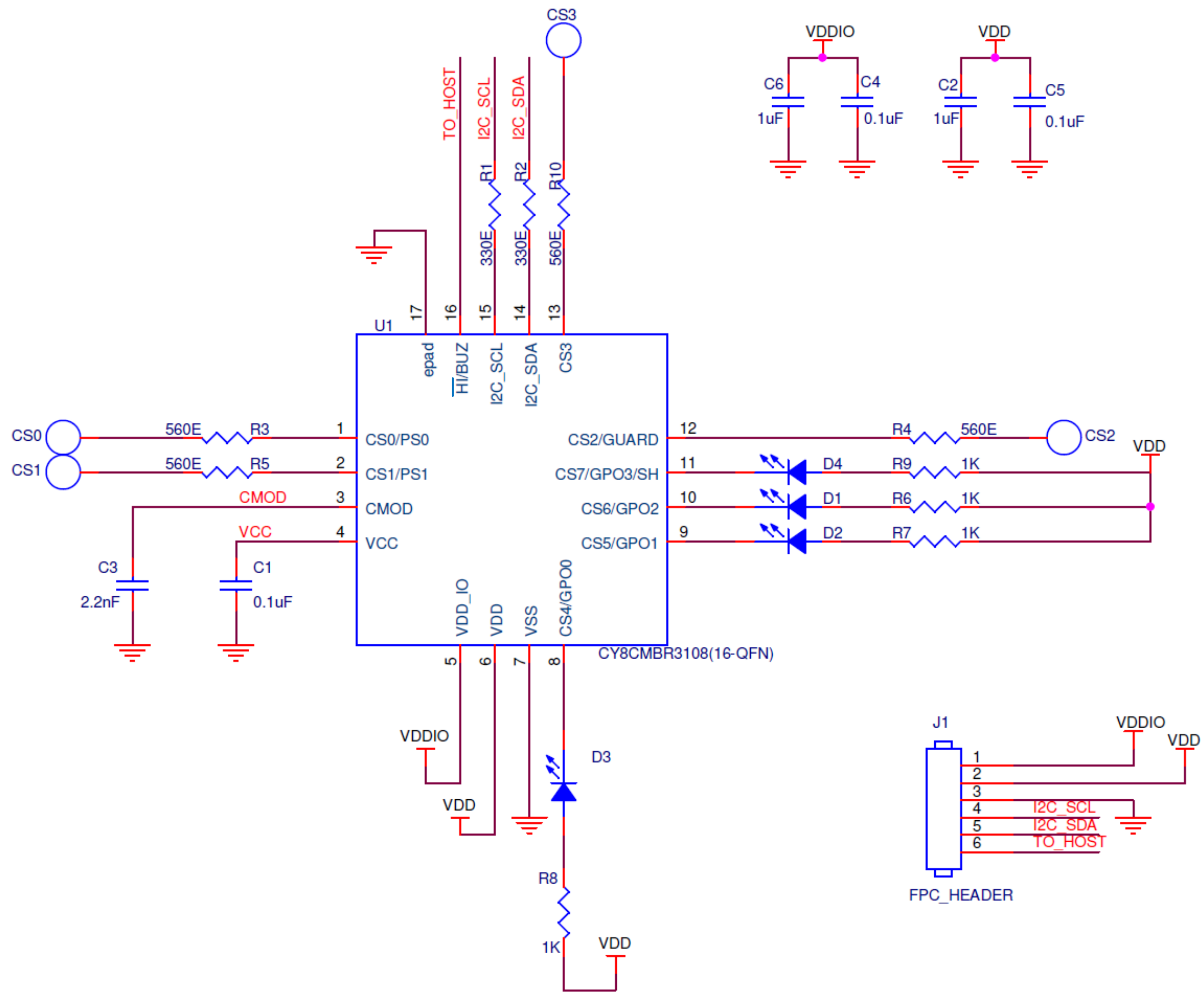
- CS0-CS3: CapSense buttons
  - All CapSense pins must have a 560-Ω series resistance (placed close to the chip) for improved noise immunity.
- GPO0-GPO3: To external LEDs
  - LEDs are connected in sinking mode because the CY8MBR3xxx controller has high sink current capability.
  - Series resistances are connected to limit the GPO current to be with I_{IL} limits.
- CMOD pin: 2.2 nF to ground
- VCC pin: 0.1 µF to ground.
  - Supply voltage is 3.3 V and therefore, the VCC pin is not shorted to the VDD pin.
- VDD pin: To external supply voltage
  - 1 µF and 0.1 µF decoupling capacitor connected to VDD pin.
- VDDIO pin: To supply voltage, which is ≤ VDD
  - VDDIO powers I^2C and HI lines.
- I^2C_SCL and I^2C_SDA pins: 330 ohms to the I^2C header

[1] VDD: This is the primary supply to the chip and can be powered from 1.8 V ±5% or 1.8 to 5.5 V
[2] VCC: This is the internal regulator output, which powers the core and capacitive sensing circuits
[3] VDDIO: This is the supply input for I^2C SDA, I^2C SCL, and HI lines in CY8CMBR3108. The signal levels of these I/Os are referenced with respect to VDDIO. For more details on power supply information refer to CY8CMBR3xxx Datasheet
[4] SDA – Serial Data (SDA) line is used to send data between the I^2C master and the I^2C slave
[5] SCL - Serial Clock (SCL) line is used to synchronize the I^2C slave with the I^2C master
[6] Refer to the Pinouts section in the CY8CMBR3xxx Datasheet for details on the pin connection when not used

[7] The system diagnostics feature when enabled, will report these pins as short to ground

- HI pin: To host
  - To prompt the host to initiate an I^{2}C transaction for reading the changed sensor status.

Figure 3-6. Schematic for Touch Buttons in Mobile Phone



Notes:

- Place capacitors C1, C2, C3, C4, C5, C6 and 560 Ω series resistors as close as possible to CapSense IC
- I^{2}C lines (SDA and SDL) and HI requires external pull-up resistors on the host side.

Table 3-3. Bill of Materials

No.	Qty.	Reference	Description	Manufacturer	Manufacturer Part No.
1	2	C1, C4, C5	CAP CER 0.1 µF 10 V 10% X5R 0402	Taiyo Yuden	LMK105BJ104KV-F
2	1	C2, C6	CAP CER 1 µF 10 V 10% X5R 0402	TDK Corporation	C1005X5R1A105K050BB
3	1	C3	CAP CER 2200 pF 50 V 5% X7R 0402	Murata	GRM155R71H222JA01J
4	2	R1, R2	RES 330 Ω 1/10 W 5% 0402 SMD	Panasonic Electronic Components	ERJ-2GEJ331X
5	4	R3, R4, R5, R10	RES 560 Ω 1/16 W 5% 0402 SMD	Yageo Corporation	RC0402JR-07560RL

No.	Qty.	Reference	Description	Manufacturer	Manufacturer Part No.
6	4	R6, R7, R8, R9	RES 1 kΩ 1/10 W 5% 0402 SMD	Panasonic Electronic Components	ERJ-2GEJ102X
7	1	U1	CY8CMBR3108-LQXI-16QFN	Cypress Semiconductor	CY8CMBR3108-LQXI -16QFN
8	4	D3, D2, D1, D4	LED CHIP ANGAN HER RA 0603	Avago Technologies US Inc.	516-2277-1-ND

3.3.2 Touch Buttons in Home Appliances

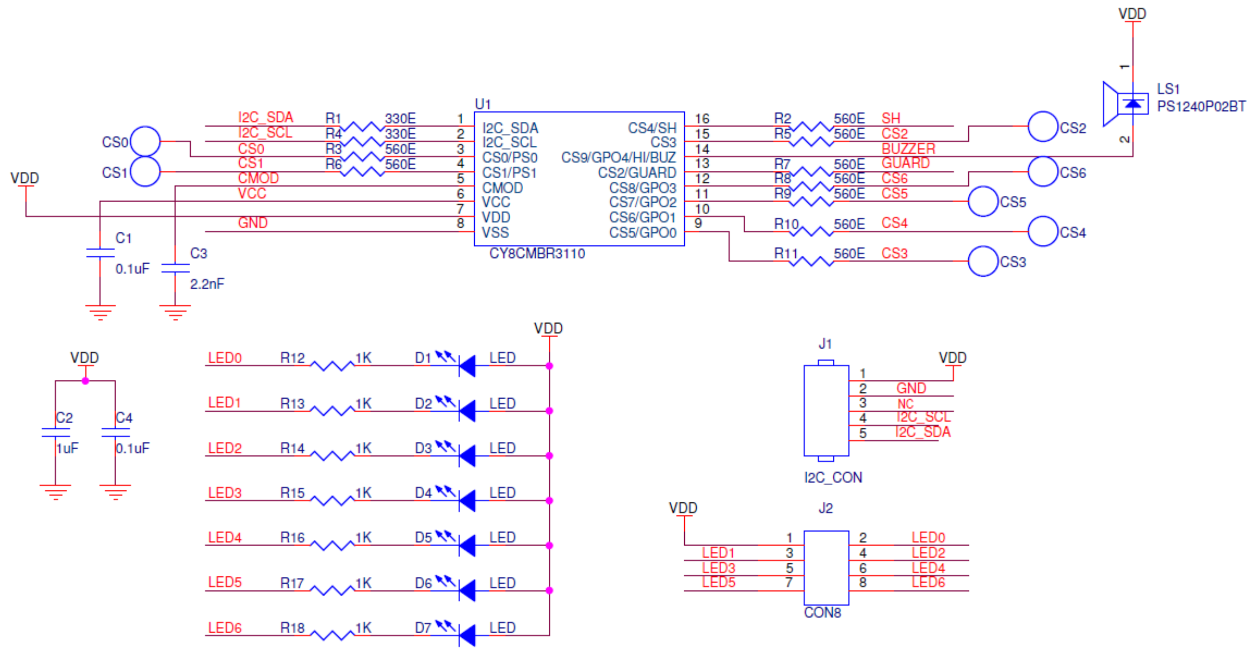
Touch buttons are used in home appliances to replace mechanical buttons. The key requirements in these applications are water tolerant CapSense buttons and audio feedback.

The schematic shown in Figure 3-7 is an example of implementing touch buttons in an induction cooktop.

In the Figure 3-7, the CY8CMBR3110 controller is configured in the following manner:

- CS0, CS1, CS3, CS5, CS6, CS7, CS8: CapSense buttons
  - All CapSense pins must have a 560 Ω series resistance (placed close to the chip) for improved noise immunity.
- SH: Shield pin
  - Shield pin must have a 560 Ω series resistance (placed close to the chip) for improved noise immunity.
- GUARD: Guard sensor
  - Guard sensor must have a 560 Ω series resistance (placed close to the chip) for improved noise immunity.
- BUZZER: To connect 1-pin buzzer
- CMOD pin: 2.2 nF to ground
- VCC pin: 0.1 µF to ground (Device)
  - Supply voltage is 5 V and therefore, the VCC pin is not shorted to the VDD pin.
- VDD pin: To external supply voltage
  - 1 µF and 0.1 µF decoupling capacitor connected to the VDD pin.
- I^2C_SCL and I^2C_SDA pins: 330 Ω to the I^2C header.

Figure 3-7. Schematic for Touch Buttons in Induction Cooker



Notes:

- Place the capacitors C1, C2, C3, C4 and 560 Ω series resistors as close as possible to CapSense IC

- The LEDs shown in this schematic are driven by the host controller based on the sensor status.
- I^{2}C lines (SDA and SDL) require external pull-up resistors on the host side.

Table 3-4. Bill of Materials

No.	Qty.	Reference	Description	Manufacturer	Manufacturer Part No.
1	2	R1, R4	RES 330 Ω 1/10 W 5% 0603 SMD	Yageo Corporation	RC0603JR-07330RL
2	9	R3, R6, R2, R5, R7, R8, R9, R10, R11	RES 560 Ω 1/10 W 5% 0603 SMD	Yageo Corporation	RC0603JR-07560RL
3	1	C1, C4	CAP CER 0.1 µF 10 V 10% X5R 0603	AVX Corporation	0603ZD104KAT2A
4	1	C2	CAP CER 1 µF 10 V 10% X5R 0603	TDK Corporation	C1608X5R1A105K080AC
5	1	C3	CAP CER 2200 pF 50 V 5% NP0 0603	Murata	GRM1885C1H222JA01D
6	1	U1	CY8CMBR3110-SX2I-16SOIC	Cypress Semiconductor	CY8CMBR3110-SX2I-16SOIC
7	1	LS1	Buzzer Piezo 4 kHz 12.2 mm PC MNT	TDK Corporation (VA)	PS1240P02BT
8	7	D1, D2, D3, D4, D5, D6, D7, D8	LED Red Clear 1206 REAR MNT SMD	Stanley Electric Co	BR1111R-TR
9	7	R12, R13, R14, R15, R16, R17, R18	RES 1.0 kΩ 1/10 W 5% 0603 SMD	Yageo	RC0603JR-071KL
10	1	J1	CONN HDR 100" SNGL PCB 5POS	Sullins Connector Solutions	SWR25X-NRTC-S05-ST-BA
11	1	J2	CONN HEADER .100" DUAL STR 80POS	Sullins Connector Solutions	PRPC040DAAN-RC

3.3.3 Proximity Sensing

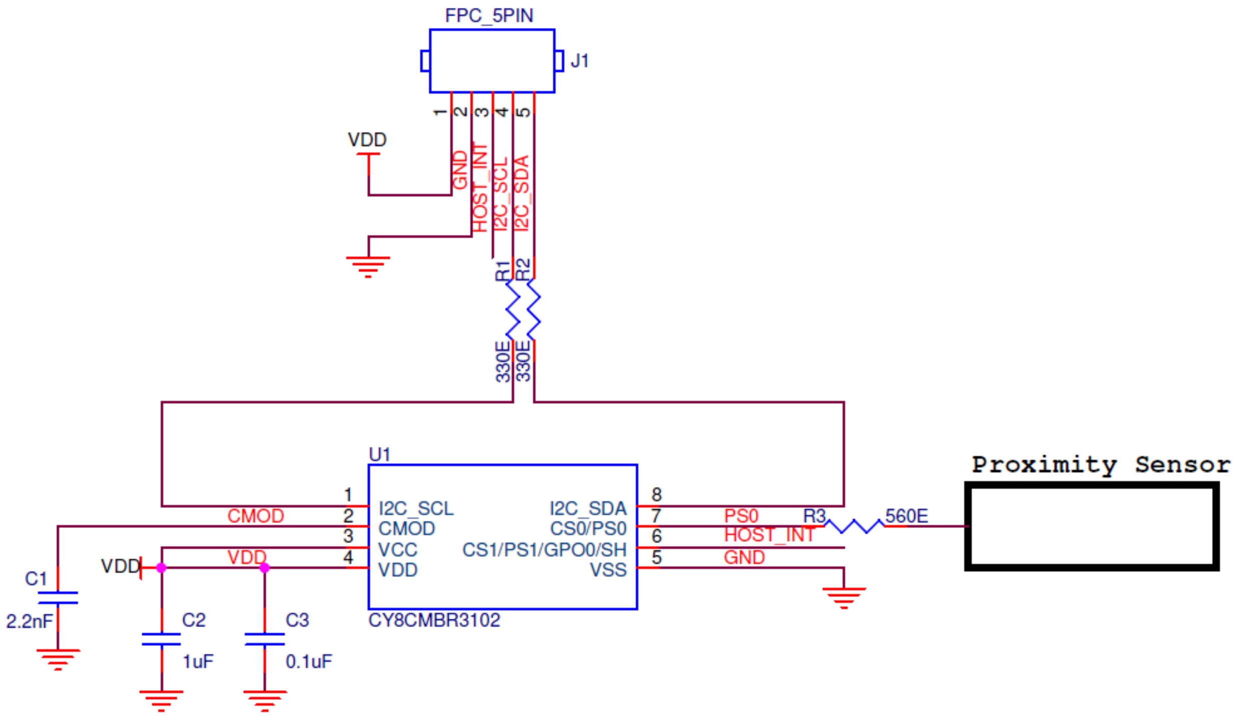
Proximity sensing is used in mobile phones/tablets to turn OFF the display/disable keypad when the user is in a call and the phone is close to the ear. Proximity sensing is also used in mobile phones/tablets for Specific Absorption Rate (SAR) regulation.

The schematic shown in Figure 3-8 is an example of implementing proximity sensing in mobile phones/tablets.

In Figure 3-8, the CY8CMBR3102 controller is configured in the following manner:

- PS0: Proximity Sensor
  - All proximity sensor pins must have a 560 Ω series resistance (placed close to the chip) for improved noise immunity.
- GPO0: To Host
  - GPO is used to indicate proximity sensor status to host controller
- CMOD pin: 2.2 nF to ground
- VCC pin: Shorted to the VDD pin for 1.71 to 1.89 V operation
- VDD pin: To external supply voltage
  - 1 µF and 0.1 µF decoupling capacitor connected to the VDD pin.
- I^{2}C_SCL and I^{2}C_SDA pins: 330 Ω to the I^{2}C.

Figure 3-8. Schematic for Proximity-Sensing Application



Notes:

- Place the capacitors C1, C2, C3 and 560 Ω series resistor as close as possible to the CapSense IC
- I^{2}C lines (SDA and SCL) and Host_INT pin require a pull-up resistor on the host side.

Table 3-5. Bill of Materials

No.	Qty.	Reference	Description	Manufacturer	Manufacturer Part No.
1	1	C1	CAP CER 2200 pF 50 V 5% X7R 0402	Murata	GRM155R71H222JA01J
2	1	C2	CAP CER 1 µF 10 V 10% X5R 0402	TDK Corporation	C1005X5R1A105K050BB
3	1	C3	CAP CER 0.1 µF 10 V 10% X5R 0402	Taiyo Yuden	LMK105BJ104KV-F
4	1	R3	RES 560 Ω 1/16 W 5% 0402 SMD	Yageo Corporation	RC0402JR-07560RL
5	2	R1, R2	RES 330 Ω 1/10 W 5% 0402 SMD	Panasonic Electronic Components	ERJ-2GEJ331X
6	1	U1	CY8CMBR3102-SX1I-8SOIC	Cypress Semiconductor	CY8CMBR3102-SX1I-8SOIC

4. CapSense Layout Guidelines

In a typical CapSense application, capacitive sensors are constructed with traces on a FR4/FR2 or flexible printed circuit (FPC). Designing the CapSense layout is an important step in the design phase and following the CapSense layout best practices will help your design achieve higher noise immunity, lower parasitic capacitance (C_P), and higher signal-to-noise ratio (SNR).

The following factors should be considered while designing the CapSense layout:

- Parasitic capacitance (C_P): A high sensor C_P makes it more difficult to sense small changes in sensor capacitance and thereby reduces sensitivity. The CapSense layout should be such that the C_P of the sensor is kept to the minimum.
- Trace length: Longer trace lengths add to the sensor C_P and reduce the sensor sensitivity. Also, a long trace acts like an antenna and reduces the noise immunity of the sensor.
- Sensor dimensions: The sensor dimensions depend on the overlay thickness. A thicker overlay requires larger sensor dimensions.
- Power consumption: The power consumption of the sensor depends on the C_P of the sensor. Higher sensor C_P increases the scan time of the sensor, and results in higher overall power consumption. To achieve lower power consumption, reduce the sensor C_P.

To achieve lower C_P, higher SNR, and lower power consumption, follow the layout best practices. The CY8CMBR3xxx Design Toolbox helps in achieving these goals.

4.1 Design Toolbox

CY8CMBR3xxx Design Toolbox is a spreadsheet that provides general layout guidelines, estimation of sensor dimensions, parasitic capacitance estimation, average current consumption, and response time of sensors. The design toolbox can be accessed from EZ-Click. The latest version of the design toolbox can be downloaded from CY8CMBR3xxx Design Toolbox.

This toolbox has four different sections:

1. General Layout Guidelines
2. Layout Estimator
3. C_P, Power Consumption, and Response Time Calculator
4. Design Validation

4.1.1 General Layout Guidelines

This sheet provides recommendations on the sensor shape, minimum and maximum sensor dimensions, placement of the sensor, and routing traces on the PCB or FPC. Follow these guidelines for designing the CapSense layout.

Table 4-1 summarizes the layout guidelines designing a CapSense application. For a detailed review of these guidelines, see the Getting Started with CapSense guide.

Table 4-1. Layout Recommendations

#	Category	Details	Min	Max	Recommendations/Remarks
1	**Button**	Button Parasitic Capacitance (Cp)	5 pF	45 pF	Lower the button Cp, higher the sensitivity and lower the power consumption
2		Button shape	NA	NA	Solid round pattern, round with LED hole, or rectangle with round corners
3		Button size	5 mm	15 mm	See the Layout Estimator sheet
4		Button-button spacing	equal to button ground clearance	NA	8 mm
5		Button-ground clearance	0.5 mm	2 mm	Equal to overlay thickness, but within min/max limits
6	**Slider**	Slider segment Parasitic Capacitance (Cp)	5 pF	45 pF	Lower the slider segment Cp, higher the sensitivity and lower the power consumption
7		Slider Segment Shape (Linear Slider)	NA	NA	Zigzag pattern (double chevron)
8		Width of Slider Segment	1.5 mm	4 mm	Equal to overlay thickness, but within the min/max limits
9		Height of the Slider segment	7 mm	15 mm	12 mm
10		Slider Segment-ground clearance	0.5 mm	2 mm	Equal to overlay thickness, but within the min/max limits
11		Clearance between Slider segments	0.5 mm	2 mm	Equal to the sensor-to-ground clearance
12	**Proximity Sensor**	Proximity sensor Parasitic Capacitance (Cp)	8 pF	45 pF	Lower the proximity sensor Cp, higher the proximity detection range
13		Proximity sensor shape	NA	NA	• Circular or rectangular (curved edges) loop on PCB for large area • Circular or rectangular solid fill for small area. • It is recommended to have a ground loop surrounding the proximity sensor.
14		Proximity sensor trace width	1.5 mm		1.5 mm
15		Clearance between proximity loop and ground loop	1 mm		1 mm
16		Ground loop trace width	1.5 mm		1.5 mm
17		Proximity sensor loop diameter	As described in Recommendation Column	As described in Recommendation Column	Loop diameter should at least be equal to required proximity distance if ALP filter is disabled. If ALP filter is enabled, loop diameter should be at least equal to half of required proximity distance. Any ground metal/plane near the proximity loop sensor will decrease the proximity distance.

#	Category	Details	Min	Max	Recommendations/Remarks
18	Guard	Guard sensor Parasitic Capacitance (Cp)	5 pF	45 pF	Lower the guard sensor Cp, higher the sensitivity and lower the power consumption
19		Guard sensor shape	NA	NA	Rectangular PCB trace with curved edges and should surround all the button sensor
20		Guard sensor thickness	2 mm		2 mm
21	Ground/ Shield	Ground /Shield flood- top layer	As described in Recommendation Column	As described in Recommendation Column	Hatched pattern 0.17 mm (7 mil) trace and 1.143 mm (45 mil) grid (15% filling)
22		Ground/Shield flood - bottom layer	As described in Recommendation Column	As described in Recommendation Column	Hatched pattern 0.17 mm (7 mil) trace and 1.778 mm (70 mil) grid (10% filling). For CapSense designs on FPC there should not be any ground fill in the bottom layer.
23	Routing	Placement of components in two layer PCB	NA	NA	• Top layer: Sensors • Bottom layer: Device, other components, and traces.
24		Placement of components in four layer PCB	NA	NA	• Top layer: Sensors • Second layer: CapSense traces and $V_{DD.}$ Avoid V_{DD} traces below sensors • Third layer: Hatched ground • Bottom layer: Device, other components and non-CapSense traces
25		Trace length from sensor pad to device pin		520 mm	520 mm is for FR4 PCB, with a button diameter of 5 mm. For a different design, refer to Layout Estimator sheet. Shorter the trace lower will be the sensor Cp.
26		Trace width (FR4/FR2/FPC)	0.17 mm	0.20 mm	0.17 mm (7 mil)
27		Trace routing	NA	NA	Traces should be routed on the non sensor side. If any non-CapSense trace crosses the CapSense trace, ensure that the intersection is orthogonal.
28		Via position for the sensors	NA	NA	Via should be placed near the edge of the button to reduce trace length, thereby increasing the sensitivity.
29		Via hole size for sensor traces			10 mil
30		Number of via on sensor trace	1	2	1
31		CapSense series resistor placement		10 mm	Place CapSense series resistors close to the device for noise suppression. CapSense resistors have higher priority than LED resistors. Place them first.

#	Category	Details	Min	Max	Recommendations/Remarks
32		Distance between any CapSense trace to ground flood	0.254 mm (10 mil)	0.508 mm (20 mil)	0.508 mm (20 mil)
33		Device placement	NA	NA	Mount the device on the layer opposite to the sensor. The CapSense trace length between the device and sensors should be minimum (see trace length above)
34		LED backlighting	NA	NA	Cut a hole in the sensor pad and use rear mountable LEDs.
35		Board thickness	As described in Recommendation Column	As described in Recommendation Column	Standard board thickness for CapSense FR4 based designs is 1.6 mm
36	**Overlay**	Overlay thickness	As per design requirement	5 mm	Use layout Estimator sheet to decide overlay. Given maximum limit is for plastic overlay
37		Overlay material	NA	NA	Should be non-conductive material (glass, ABS plastic, Formica, wood, and so on). No air gap should be there between the PCB and overlay. Use adhesive to stick the PCB and overlay.
38		Overlay adhesives	NA	NA	Adhesive should be nonconductive and dielectrically homogenous. 467MP and 468MP adhesives made by 3M are recommended.

4.1.2 Layout Estimator

The Layout Estimator sheet provides recommendations for minimum sensor size and maximum trace length based on the end-system requirements and industrial design, as Figure 4-1 shows.

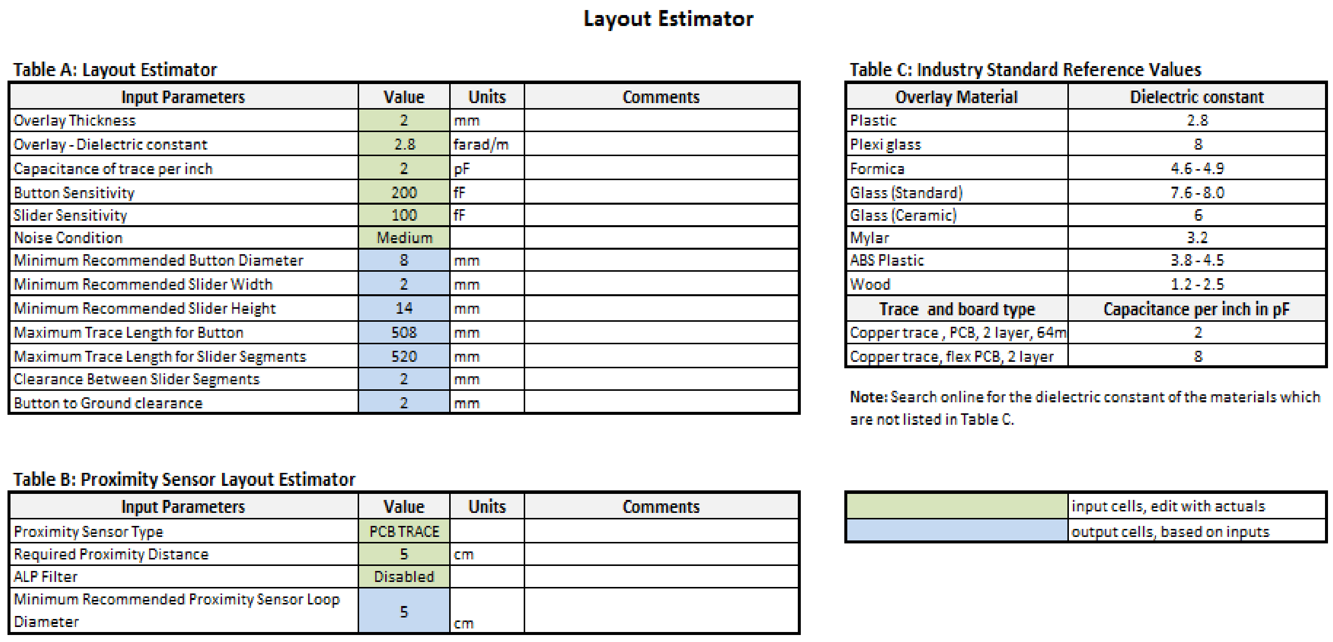
This sheet takes the following parameters as inputs:

- Overlay thickness: Enter the overlay thickness that will be used in your design. CY8CMBR3xxx supports up to 5 mm thick plastic overlay for a button sensor and up to 2 mm plastic overlay for slider sensor.
- Overlay dielectric constant: Enter the overlay dielectric constant. Refer to Table C in the sheet to know the dielectric constant of several materials. Materials with high dielectric constant results in higher sensitivity of sensors.
- Capacitance of trace per inch: Enter the capacitance of trace per inch by referring to Table C in this sheet. FR4 PCB adds less Cp when compared to FPC.
- Button sensitivity: This parameter decides the button diameter and maximum overlay thickness. Selecting 400 fF tunes the system for lowest sensitivity and selecting 100 fF tunes the system for highest sensitivity.
- Slider sensitivity: If your design has a slider, then enter the sensitivity of the slider. Thicker overlays require lower values of sensitivity.
- Noise condition: The noise condition is a factor in deciding the sensor dimension. If your design is required to operate in a high-noise environment, then select “High”. If the noise condition is not known, select “Medium”.
- Proximity sensor type: If your design requires a proximity sensor, then select the proximity sensor type.
- Proximity distance required: Select the required proximity distance. Valid range is 1-30 cm.
- ALP filter: If your design requires a higher proximity distance with smaller loop size, then select “Enabled” otherwise, select “Disabled”. When the Advanced Low-Pass (ALP) filter is enabled, the response time of the proximity sensor increases.

Based on the inputs entered, the toolbox estimates the following:

- Minimum button diameter required to achieve 5:1 SNR: If the button diameter required to achieve 5:1 SNR is greater than 15 mm, the toolbox shows a warning to reduce the overlay thickness or increase the sensitivity of the sensor.
- Minimum slider dimension required to achieve 5:1 SNR: The toolbox shows a warning when the required slider dimensions are out of range. In such cases, reduce the overlay thickness or decrease the sensitivity of the sensor.
- Maximum allowed trace length in the design for button and slider sensors.
- Clearance between slider segments and the button-to-ground clearance.
- Minimum proximity loop diameter required to achieve required proximity distance with 5:1 SNR.

Figure 4-1. Layout Estimator



Layout Estimator

Table A: Layout Estimator

Input Parameters	Value	Units	Comments
Overlay Thickness	2	mm	
Overlay - Dielectric constant	2.8	farad/m	
Capacitance of trace per inch	2	pF	
Button Sensitivity	200	fF	
Slider Sensitivity	100	fF	
Noise Condition	Medium		
Minimum Recommended Button Diameter	8	mm	
Minimum Recommended Slider Width	2	mm	
Minimum Recommended Slider Height	14	mm	
Maximum Trace Length for Button	508	mm	
Maximum Trace Length for Slider Segments	520	mm	
Clearance Between Slider Segments	2	mm	
Button to Ground clearance	2	mm	

Table C: Industry Standard Reference Values

Overlay Material	Dielectric constant
Plastic	2.8
Plexi glass	8
Formica	4.6 - 4.9
Glass (Standard)	7.6 - 8.0
Glass (Ceramic)	6
Mylar	3.2
ABS Plastic	3.8 - 4.5
Wood	1.2 - 2.5
Trace and board type	**Capacitance per inch in pF**
Copper trace , PCB, 2 layer, 64m	2
Copper trace, flex PCB, 2 layer	8

Note: Search online for the dielectric constant of the materials which are not listed in Table C.

Table B: Proximity Sensor Layout Estimator

Input Parameters	Value	Units	Comments
Proximity Sensor Type	PCB TRACE		
Required Proximity Distance	5	cm	
ALP Filter	Disabled		
Minimum Recommended Proximity Sensor Loop Diameter	5	cm	

🟩	input cells, edit with actuals
🟦	output cells, based on inputs

4.1.3 C_P, Power Consumption, and Response Time Calculator

After the board layout has been completed, the C_P, average current consumption and response time of your design can be estimated using the C_P, Power Consumption and Response Time Calculator sheet.

4.1.3.1 *Estimating the C_P Value*

Follow these steps to estimate the C_P of the sensor:

1. In Table A, select the part number from the drop down list.
2. If the part number selected is "CY8C3106S" and sliders are required in the design, enter the number of sliders and number of segments in each slider group.
3. In Table B, select the type of the sensor from the "Sensor Type" column. For a pin that is not connected to any sensor or not applicable for the selected part number, select NC (no connection). Refer to the CY8CMBR3xxx datasheet for the pin details.
4. Enter the sensor dimensions for the selected sensor. The "Slider Length" column is applicable only for slider segments. If the entered sensor dimension exceeds the maximum range, the toolbox alerts to reduce the sensor dimension. Refer to the General Layout Guidelines to find the minimum and maximum sensor dimensions.
5. Enter the trace length of each sensor in the "Trace Length" column.
6. When all these parameters are entered, the toolbox estimates the sensor C_P value and displays it in the "Parasitic capacitance (Cp) of sensors" column. If the estimated C_P value is more than 45 pF, then decrease the trace length until the C_P value is less than 45 pF. Reducing the sensor dimension is not recommended if its value is within the maximum limit.

Figure 4-2. Estimating the C_P of Sensors

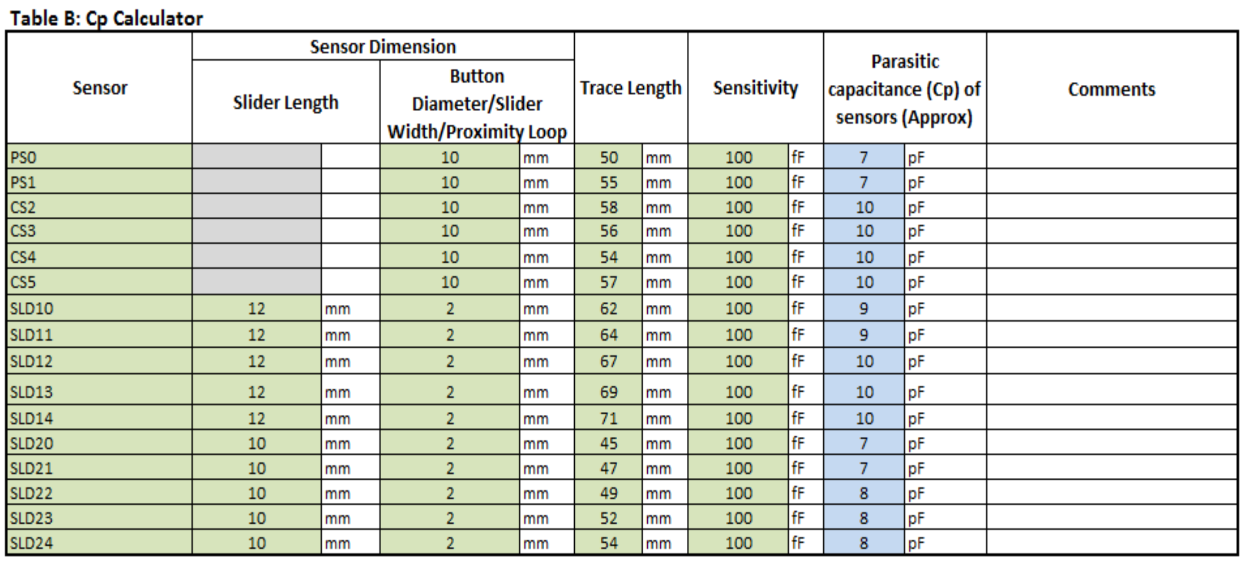


Table B: Cp Calculator

Sensor	Sensor Dimension				Trace Length		Sensitivity		Parasitic capacitance (Cp) of sensors (Approx)		Comments
	Slider Length		Button Diameter/Slider Width/Proximity Loop								
PS0			10	mm	50	mm	100	fF	7	pF	
PS1			10	mm	55	mm	100	fF	7	pF	
CS2			10	mm	58	mm	100	fF	10	pF	
CS3			10	mm	56	mm	100	fF	10	pF	
CS4			10	mm	54	mm	100	fF	10	pF	
CS5			10	mm	57	mm	100	fF	10	pF	
SLD10	12	mm	2	mm	62	mm	100	fF	9	pF	
SLD11	12	mm	2	mm	64	mm	100	fF	9	pF	
SLD12	12	mm	2	mm	67	mm	100	fF	10	pF	
SLD13	12	mm	2	mm	69	mm	100	fF	10	pF	
SLD14	12	mm	2	mm	71	mm	100	fF	10	pF	
SLD20	10	mm	2	mm	45	mm	100	fF	7	pF	
SLD21	10	mm	2	mm	47	mm	100	fF	7	pF	
SLD22	10	mm	2	mm	49	mm	100	fF	8	pF	
SLD23	10	mm	2	mm	52	mm	100	fF	8	pF	
SLD24	10	mm	2	mm	54	mm	100	fF	8	pF	

4.1.3.2 *Estimating the Average Current*

After the sensor dimensions are entered as shown in the Estimating the CP Value section, use the following steps to estimate the average current consumption of the controller:

1. In Table B, select the sensitivity of each sensor from the “Sensitivity” column. The higher the value of sensitivity, the lower the current consumption.
2. In Table C, select the scan period. The higher the scan period value, the lower the average current consumption.
3. Select the State Timeout period. The lower the value of timeout period, the lower the power consumption. Select this value based on your design requirements.
4. If EMC is enabled, select “Enabled”; otherwise select “Disabled”.
5. Select the Buzzer ON Time value if buzzer is enabled; otherwise select 0. When the buzzer is enabled, the average current consumption increases with the increase in the Buzzer ON Time value.
6. If PWM is enabled on GPOs, select “Enabled”; otherwise select “Disabled”.
7. Enter the average number of touches in an hour and the duration of each sensor touch. This value depends on how frequently the user touches the sensors.
8. When all these parameters are entered, the toolbox displays the estimated average current consumption per hour, as Figure 4-3 shows.

Figure 4-3. Average Current Consumption Estimation

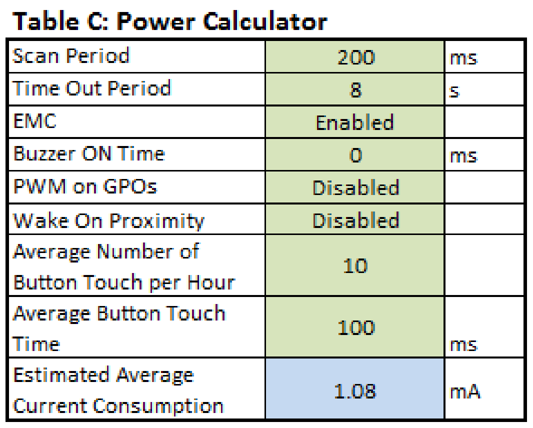


Table C: Power Calculator

Scan Period	200	ms
Time Out Period	8	s
EMC	Enabled	
Buzzer ON Time	0	ms
PWM on GPOs	Disabled	
Wake On Proximity	Disabled	
Average Number of Button Touch per Hour	10	
Average Button Touch Time	100	ms
Estimated Average Current Consumption	1.08	mA

4.1.3.3 *Estimating the Response Time*

The response time of the sensors depends on the values entered in Table B and Table C. To estimate the response time of buttons and sliders, enter the parameters in Table B and Table C as explained in section 4.1.3.1 and section 4.1.3.2 respectively.

Follow these steps to estimate the response time of buttons and sliders:

1. In Table D, select the Debounce parameter value.
2. If infinite impulse response (IIR) and median filter are enabled, select “Enabled” in their respective cells; otherwise select “Disabled”.
3. When these parameters are entered, the toolbox displays the first touch and consecutive touch response times for buttons and sliders respectively, as Figure 4-4 shows.

To estimate the response time of the proximity sensor and device timing parameters, follow these steps:

1. To estimate the response time of proximity sensor in different operating modes, select the operating state of the controller. Refer to the CY8CMBR3xxx Operating Modes section for details on each operating mode.
2. If the Advanced Low-Pass (ALP) filter is enabled, then select “Enabled”; otherwise select “Disabled”.
3. Select the Debounce parameter value.
4. When these parameters are entered, the toolbox displays the response time for proximity detection and proximity release, as Figure 4-4 shows.
5. To estimate the LED duration minimum and maximum values, select the LED duration value.

Figure 4-4. Response Time Estimation

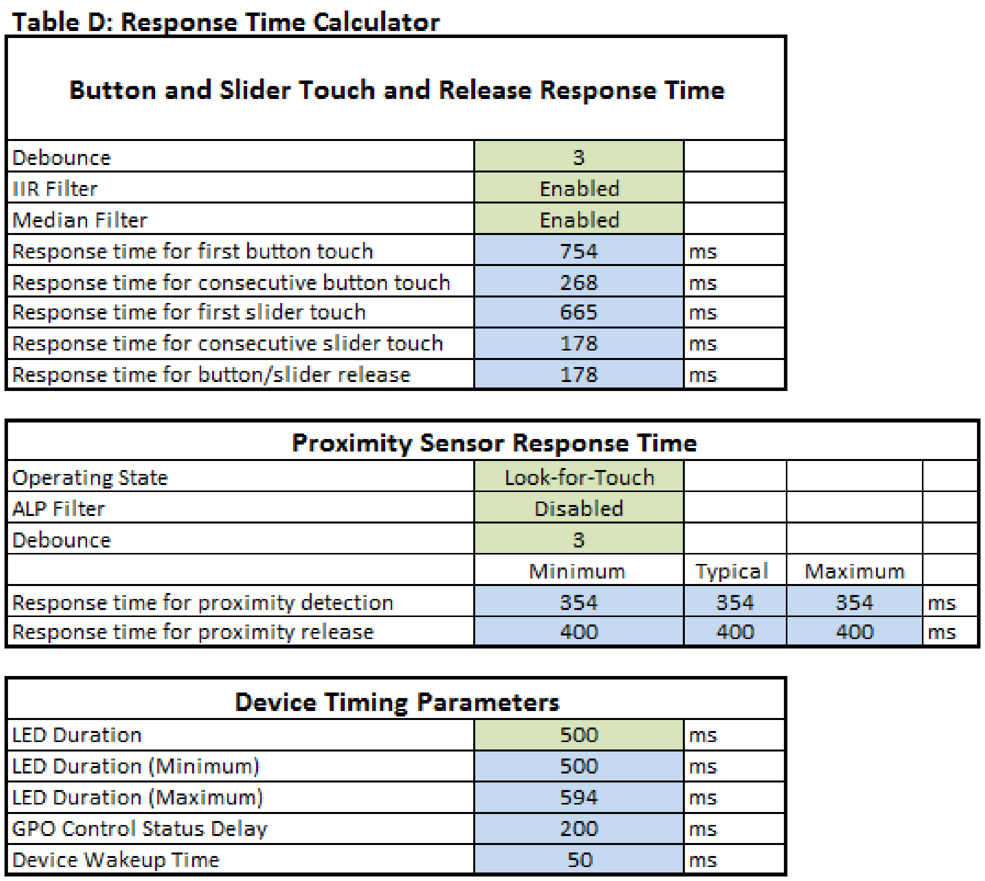


Table D: Response Time Calculator

Button and Slider Touch and Release Response Time		
Debounce	3	
IIR Filter	Enabled	
Median Filter	Enabled	
Response time for first button touch	754	ms
Response time for consecutive button touch	268	ms
Response time for first slider touch	665	ms
Response time for consecutive slider touch	178	ms
Response time for button/slider release	178	ms

Proximity Sensor Response Time				
Operating State	Look-for-Touch			
ALP Filter	Disabled			
Debounce	3			
	Minimum	Typical	Maximum	
Response time for proximity detection	354	354	354	ms
Response time for proximity release	400	400	400	ms

Device Timing Parameters		
LED Duration	500	ms
LED Duration (Minimum)	500	ms
LED Duration (Maximum)	594	ms
GPO Control Status Delay	200	ms
Device Wakeup Time	50	ms

4.1.4 Validating the Design

After the prototype board is built and tested, use the design validation sheet to verify the design. To use the design validation sheet it is required to enter the parameters in Table-B of the CP, Power Consumption, and Response Time Calculator sheet.

The “Design Validation” sheet validates only the design of buttons and slider sensors; it does not validate or provide recommendations for proximity sensor design because the design of proximity sensors depends on various external factors.

To validate your design, follow these steps:

1. Use EZ-Click to measure the raw counts, noise and C_P value for buttons and sliders.
2. Enter the raw counts, noise, and C_P value in Table C for each sensor, as Figure 4-5 shows.
3. Based on these parameters, the toolbox provides recommended sensor dimension. If the sensor dimension entered in Table-B of the CP, Power Consumption, and Response Time Calculator sheet is greater than or equal to recommended sensor dimension, the design is shown as “Pass”; otherwise it is show as “Fail”.

If the design passes, prototype stage is complete and the design is production ready.

Note: If the design has proximity sensor, the toolbox will not provide any recommendation for proximity sensor and will not validate the entire design.

If the design fails, follow these steps:

1. Reduce the sensitivity parameter value in Table B.
2. If the design still fails, reduce the overlay thickness in Table A, as Figure 4-6 shows.
3. If the design still fails after reducing the sensitivity value and reducing overlay thickness, enter the new sensor dimensions in Table B, based on the recommended values from Table C, as Figure 4-7 shows.

Note: The layout has to be re-designed based on the recommended values from Table C.

Figure 4-5. Design Validation - Sensor Dimension Recommendation Table

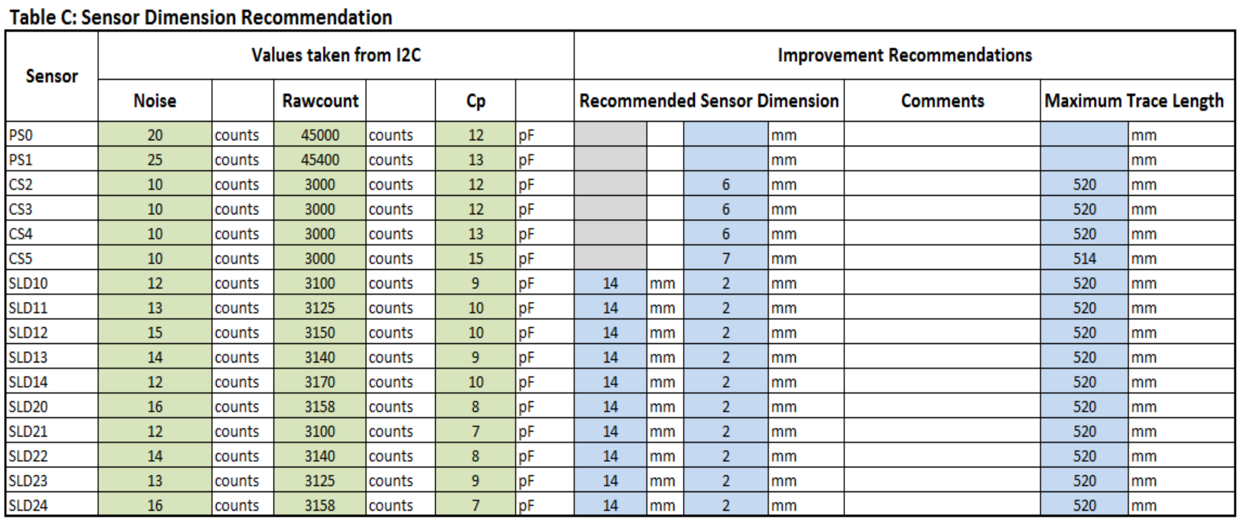


Table C: Sensor Dimension Recommendation

Sensor	Values taken from I2C						Improvement Recommendations						
	Noise		Rawcount		Cp		Recommended Sensor Dimension				Comments	Maximum Trace Length	
PS0	20	counts	45000	counts	12	pF				mm			mm
PS1	25	counts	45400	counts	13	pF				mm			mm
CS2	10	counts	3000	counts	12	pF			6	mm		520	mm
CS3	10	counts	3000	counts	12	pF			6	mm		520	mm
CS4	10	counts	3000	counts	13	pF			6	mm		520	mm
CS5	10	counts	3000	counts	15	pF			7	mm		514	mm
SLD10	12	counts	3100	counts	9	pF	14	mm	2	mm		520	mm
SLD11	13	counts	3125	counts	10	pF	14	mm	2	mm		520	mm
SLD12	15	counts	3150	counts	10	pF	14	mm	2	mm		520	mm
SLD13	14	counts	3140	counts	9	pF	14	mm	2	mm		520	mm
SLD14	12	counts	3170	counts	10	pF	14	mm	2	mm		520	mm
SLD20	16	counts	3158	counts	8	pF	14	mm	2	mm		520	mm
SLD21	12	counts	3100	counts	7	pF	14	mm	2	mm		520	mm
SLD22	14	counts	3140	counts	8	pF	14	mm	2	mm		520	mm
SLD23	13	counts	3125	counts	9	pF	14	mm	2	mm		520	mm
SLD24	16	counts	3158	counts	7	pF	14	mm	2	mm		520	mm

Figure 4-6. Design Validation – Actual Design Values Table

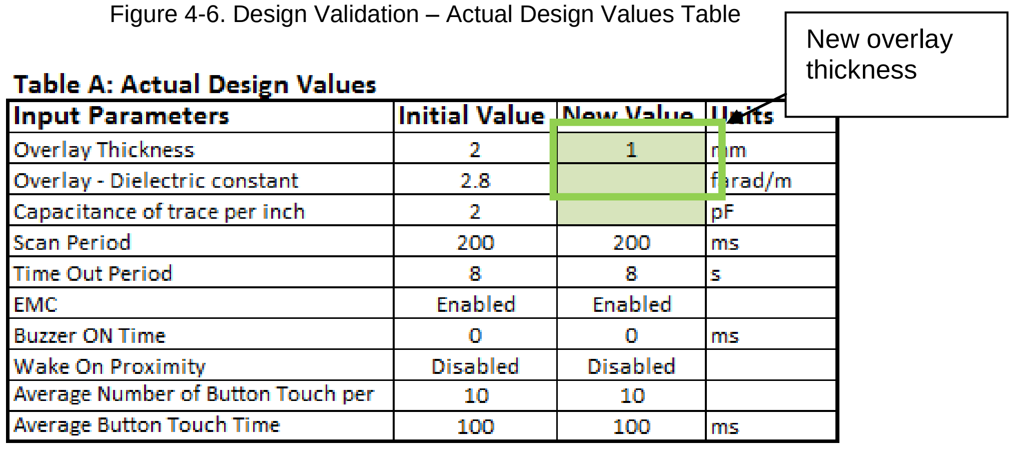

New overlay thickness

Table A: Actual Design Values

Input Parameters	Initial Value	New Value	Units
Overlay Thickness	2	1	mm
Overlay - Dielectric constant	2.8		farad/m
Capacitance of trace per inch	2		pF
Scan Period	200	200	ms
Time Out Period	8	8	s
EMC	Enabled	Enabled	
Buzzer ON Time	0	0	ms
Wake On Proximity	Disabled	Disabled	
Average Number of Button Touch per	10	10	
Average Button Touch Time	100	100	ms

Figure 4-7. Design Validation – Actual Sensor Dimensions Table

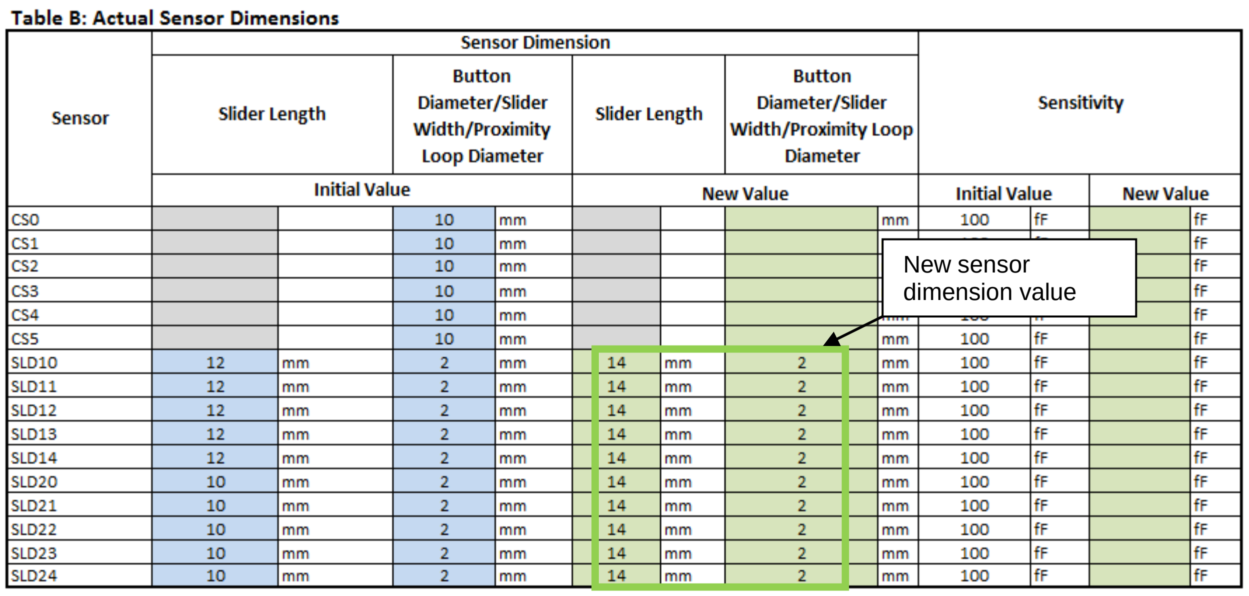

New sensor dimension value

Table B: Actual Sensor Dimensions

Sensor	Sensor Dimension								Sensitivity			
	Slider Length		Button Diameter/Slider Width/Proximity Loop Diameter		Slider Length		Button Diameter/Slider Width/Proximity Loop Diameter					
	Initial Value				New Value				Initial Value		New Value	
CS0			10	mm				mm	100	fF		fF
CS1			10	mm								fF
CS2			10	mm								fF
CS3			10	mm								fF
CS4			10	mm								fF
CS5			10	mm				mm	100	fF		fF
SLD10	12	mm	2	mm	14	mm	2	mm	100	fF		fF
SLD11	12	mm	2	mm	14	mm	2	mm	100	fF		fF
SLD12	12	mm	2	mm	14	mm	2	mm	100	fF		fF
SLD13	12	mm	2	mm	14	mm	2	mm	100	fF		fF
SLD14	12	mm	2	mm	14	mm	2	mm	100	fF		fF
SLD20	10	mm	2	mm	14	mm	2	mm	100	fF		fF
SLD21	10	mm	2	mm	14	mm	2	mm	100	fF		fF
SLD22	10	mm	2	mm	14	mm	2	mm	100	fF		fF
SLD23	10	mm	2	mm	14	mm	2	mm	100	fF		fF
SLD24	10	mm	2	mm	14	mm	2	mm	100	fF		fF

4.2 Layout Guidelines for Proximity Sensor

A capacitive proximity sensor senses nearby conductive objects without any physical contact. A proximity sensor differs from a button sensor in two different aspects: sensor construction and sensor sensitivity. Proximity sensor construction should be such that the electric field lines are projected to a maximum distance to achieve higher proximity distance. The proximity distance depends on the sensor's electrical field propagation (electrical field strength). A longer propagation distance provides a longer detection range.

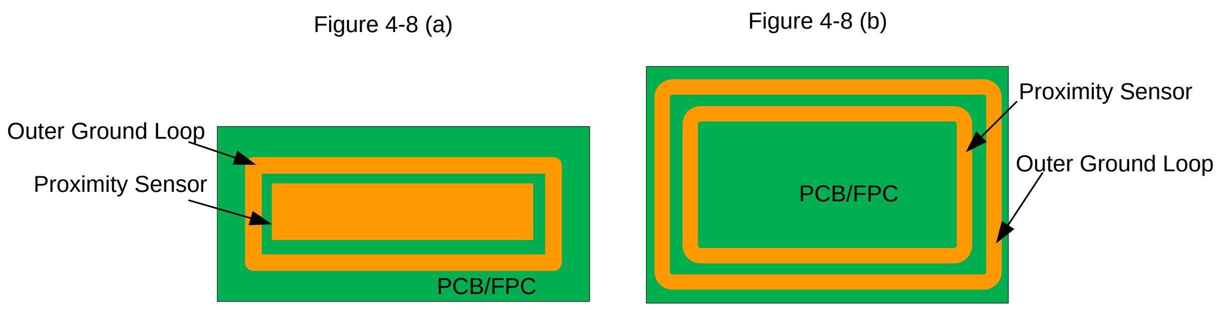
4.2.1 Sensor Design Guidelines

Proximity sensor construction depends on the intended application and the required proximity range. Applications such as face proximity detection in mobile phones and Specific Absorption Rate (SAR) regulation in tablets require proximity distance of up to 3 cm. To achieve this proximity distance, a sensor with solid fill and small area is sufficient. For applications such as photo frames, monitors, and keyboards, which require higher proximity distance, use a large sensor loop covering the circumference of the device to achieve higher proximity distance.

A proximity sensor can be constructed using the following:

- Copper trace on a PCB or FPC: A long PCB trace can be used as a proximity sensor. The trace can be a straight line, or it can surround the perimeter of a system's user interface, as Figure 4-8 shows. Proximity sensor construction using PCB trace is appropriate for mass production, but it is not as sensitive as a wire sensor. It is recommended to have a ground loop around the proximity sensor to reduce the noise and provide immunity against ESD events. There is a trade-off between proximity range and noise immunity, ESD performance. For proximity sensor and ground loop layout recommendations, refer to the General Layout Guidelines sheet of the design toolbox.

Figure 4-8. Proximity Sensor Construction on PCB/FPC

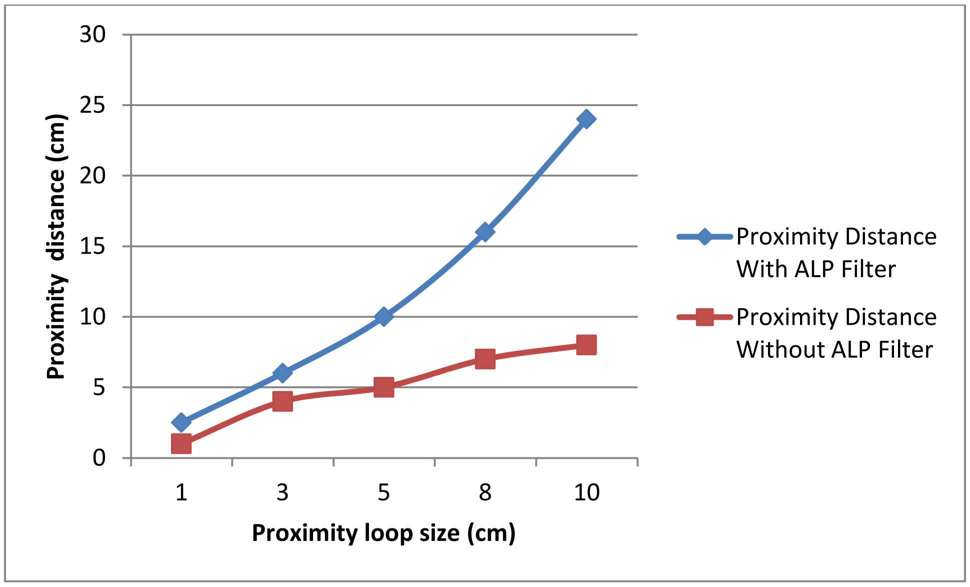


- Wire: A single length of wire works well as a proximity sensor. Because detecting a hand relies on the capacitance change from electric field changes, any stray capacitance or objects affecting the electrical field around the wire will affect the range of the proximity sensor. Using a wire sensor is not an optimal solution for mass production because of manufacturing cost and complexity.

To increase the proximity range, follow these guidelines:

- Increase the proximity sensor loop size: The proximity distance increases with increase in the proximity sensor area, as Figure 4-9 shows.
- Set the proximity resolution to maximum value: The proximity distance increases with increase in the proximity sensor resolution.
- Enable the Advanced Low-Pass (ALP) filter: The ALP filter attenuates the noise in proximity sensor raw counts and increases the proximity distance, as Figure 4-9 shows.
- Shield the proximity sensor from any nearby metal objects: Metal objects placed close to the proximity sensor reduce the sensitivity and decrease the proximity distance. Use a shield electrode to eliminate the effect of metal objects and increase the proximity distance.

Figure 4-9. Relationship Between Proximity Loop Size and Proximity Distance



Notes:

- The proximity distance shown in Figure 4-9 is measured under ideal conditions. The distance might reduce in practical applications depending on the operating environment.
- The proximity distance shown in Figure 4-9 is measured with the ground loop surrounding the proximity sensor. The clearance between the proximity loop and ground loop is kept to 1 mm.

4.2.2 Effect of Metal Objects on Proximity Distance

The proximity detection range reduces drastically if there is a metal surface near to the sensor. Most home appliances and automotive applications have a metal frame or case, so achieving a higher proximity range in these applications is very challenging.

The following factors cause the proximity detection range to reduce drastically when conductive objects are placed close to the sensor:

- The parasitic capacitance of the sensor increases. Larger stray capacitance often requires reducing the sensor operation frequency, causing the proximity distance to decrease.
- A grounded metal plane catches a part of the sensor electric field and reduces the capacitance added by the palm.

The influence of a nearby metal surface on a proximity sensor is decreased by placing a shield electrode between the proximity sensor and the metal object, as Figure 4-12 shows.

Figure 4-10. Electrical Field Propagation for a Single Sensor Configuration Without a Metal Object

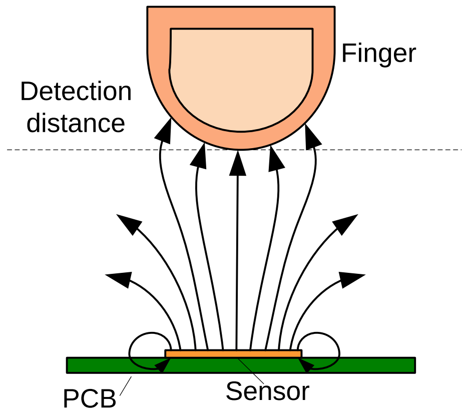


Figure 4-11. Electrical Field Propagation for a Single Sensor Configuration with a Solid Metal Object

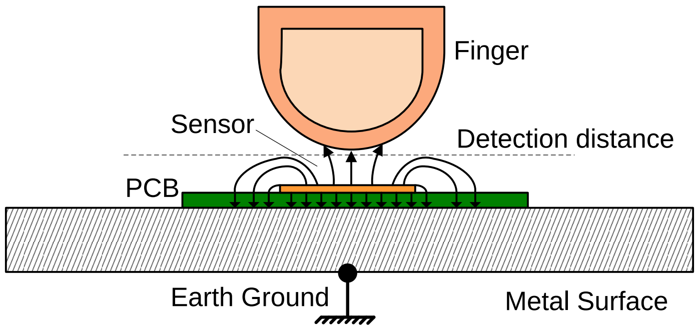
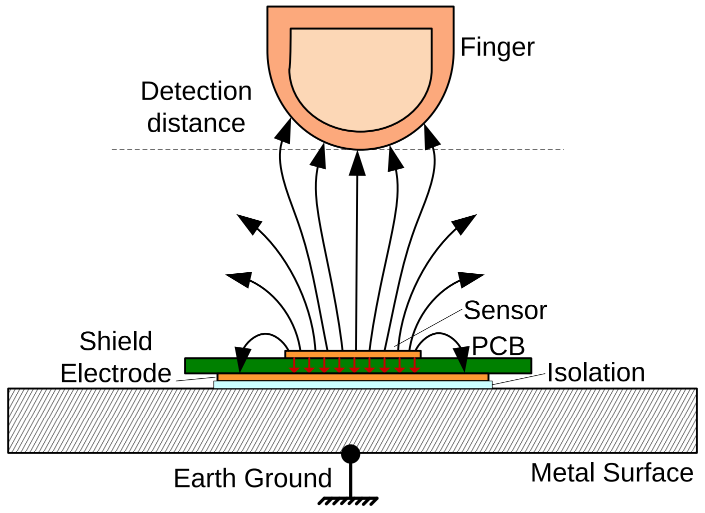


Figure 4-12. Using a Shield Electrode to Decrease the Metal Object's Influence



4.3 Layout Guidelines for Water Tolerance

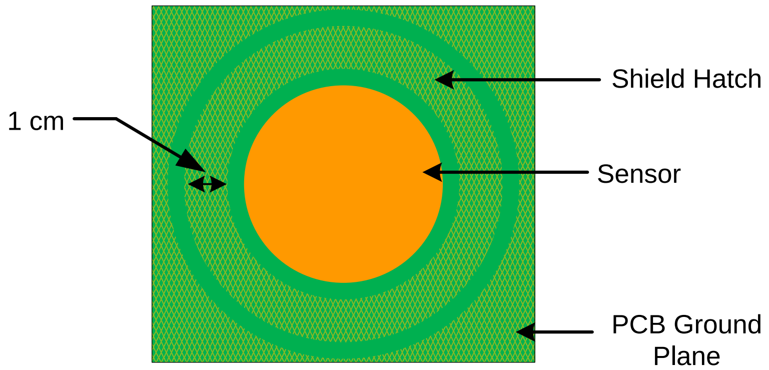
Presence of water droplets or continuous water flow on the overlay can cause capacitive touch sensors to falsely trigger. Using a shield electrode eliminates the false touches caused by the water droplets on the sensor. Similarly, using a guard sensor eliminates the false touches due to a continuous flow of water. Refer to the Water Tolerance section to understand the working of shield and guard sensors.

4.3.1 Shield Electrode Construction

Keep in mind the following guidelines to design a water-tolerant capacitive sensing application:

- Use a hatch ground of 0.17 mm (7 mil) trace and 1.143 mm (45 mil grid) in the top layer of the PCB and drive this hatch pattern with shield signal (SH pin).
- Surround the sensor pads and exposed traces (for single-layer PCB) with the shield electrode pattern.
- Keep the shield electrode spread within 1 cm from the sensor. Spreading the shield electrode beyond 1 cm has negligible effect on system performance.

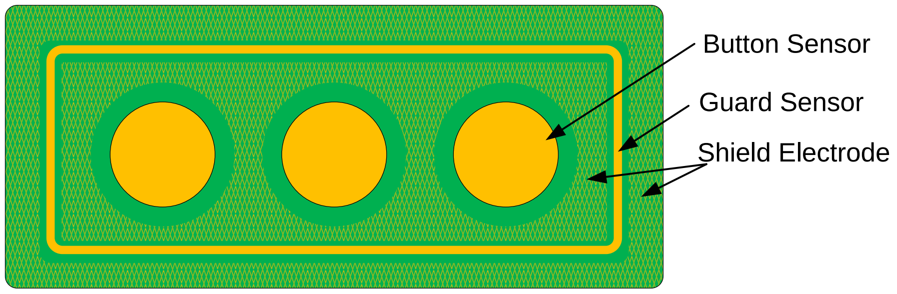
Figure 4-13. Shield Electrode Pattern



4.3.2 Guard Sensor

The guard sensor is a copper trace that surrounds all sensors, as Figure 4-14 shows. Ensure that the shield electrode pattern surrounds the guard sensor, exposed traces, and spreads no further than 1 cm from these features. The guard sensor should be in the shape of a rectangle with curved edges. The recommended thickness of a guard sensor is 2 mm, and the maximum distance between the guard trace and the shield hatch is 1 mm.

Figure 4-14. PCB Layout With Shield Electrode and Guard Sensor



4.4 Sample Layouts

4.4.1 Touch Buttons on FPC

Figure 4-15 and Figure 4-16 show the top and bottom layer of a layout designed for implementing touch buttons on FPC. For the schematic of this design, see Figure 3-6.

The following layout best practices are followed in this layout:

1. C_P of the sensor is minimized by pouring ground only in the top layer.
2. The trace length of the sensors is minimized by placing the chip close to the sensors.
3. VDD, LED and I^2C lines are isolated from sensor traces.
4. The clearance (for LED backlighting) at the center of sensor is kept to a minimum value to achieve maximum sensitivity.

Figure 4-15. Touch Buttons on FPC – Top Layer

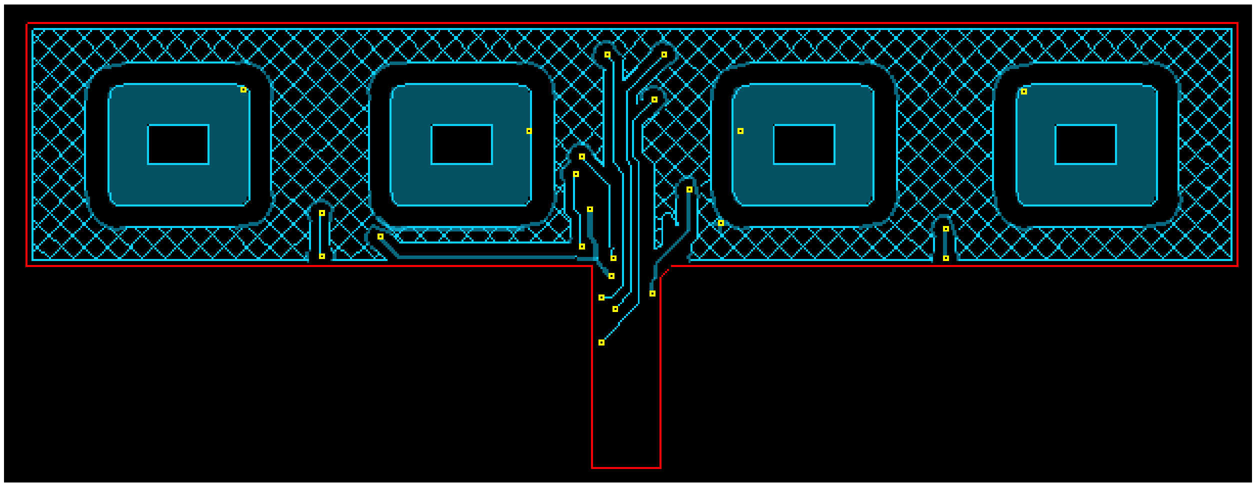
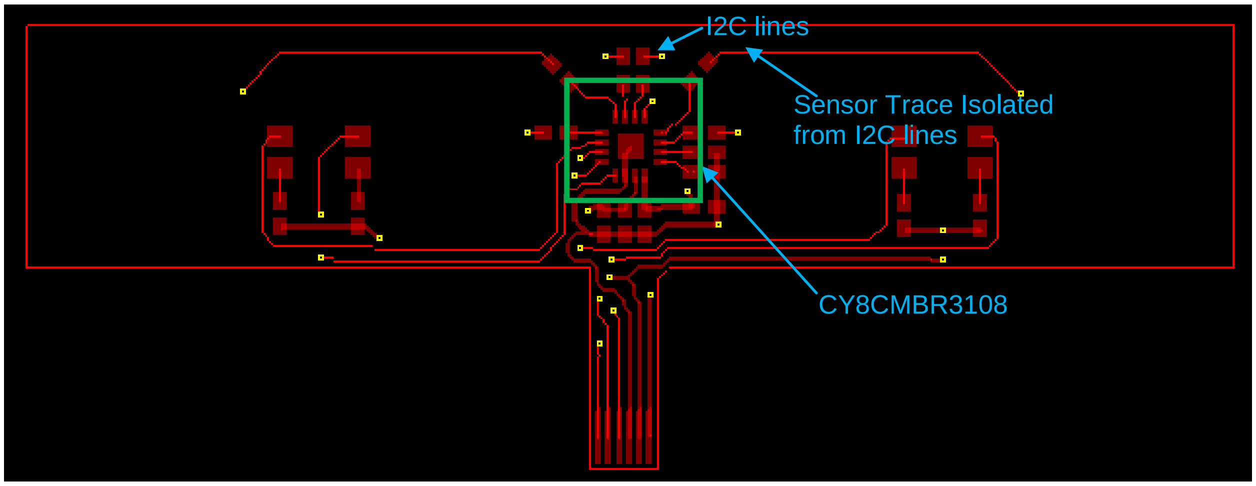


Figure 4-16. Touch Buttons on FPC – Button Layer



4.4.2 Touch Buttons on FR4 PCB

Figure 4-17 and Figure 4-18 show the top and bottom layer of a layout designed for implementing water tolerant touch buttons on FR4 PCB. For the schematic of this design, see Figure 3-7.

The following layout best practices are followed in this layout:

1. The shield and guard sensor layout is constructed as explained in the Layout Guidelines for Water Tolerance section.
2. The trace length of the sensors is minimized by placing the chip close to the sensors.
3. VDD, LED and I^{2}C lines are isolated from sensor traces.
4. The clearance (for LED backlighting) at the center of sensor is kept to a minimum value to achieve maximum sensitivity.

Figure 4-17. Water-Tolerant Touch Buttons on FR4 PCB – Top Layer

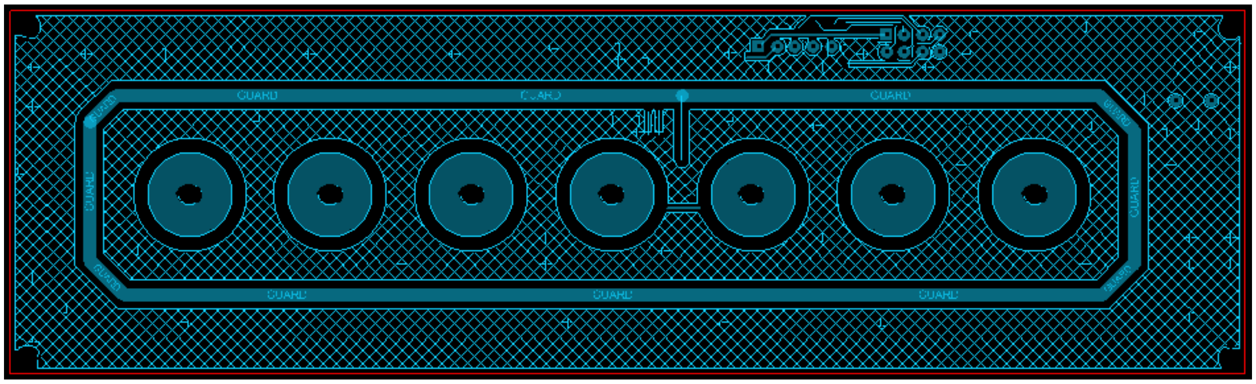
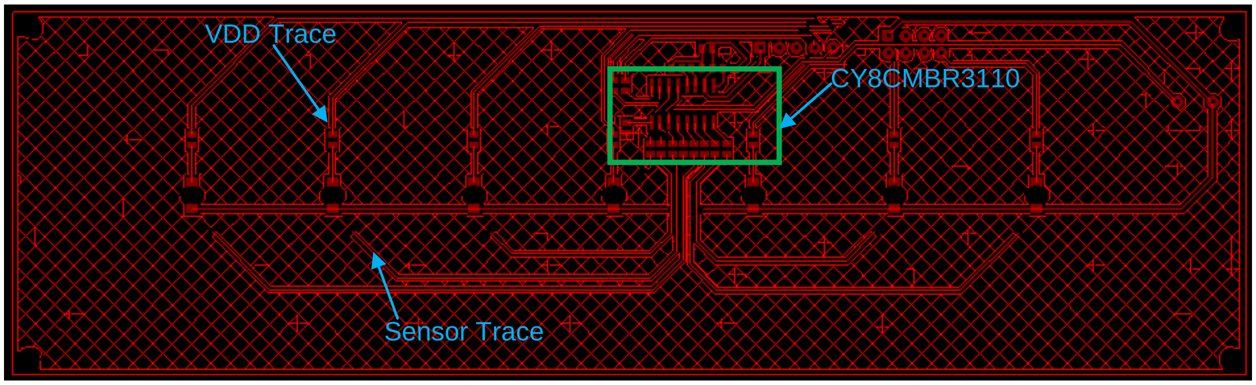


Figure 4-18. Water-Tolerant Touch Buttons on FR4 PCB – Bottom Layer



4.4.3 Proximity Sensor on FPC

Figure 4-19 and Figure 4-20 show the top and bottom layer of a layout designed for implementing a proximity sensor on FPC. For the schematic of this design, see Figure 3-8.

The following layout best practices are followed in this layout:

1. The proximity sensor loop is surrounded by a ground loop for improved noise immunity and ESD performance.
2. C_P of the sensor is minimized by using a loop sensor.
3. The proximity sensor is surrounded by a ground ring to minimize the noise. This also helps in providing immunity against ESD events.
4. The trace length of the sensor is minimized by placing the chip close to the sensor.
5. VDD and I^{2}C lines are isolated from sensor traces.

Figure 4-19. Proximity Sensor on FPC –Top Layer

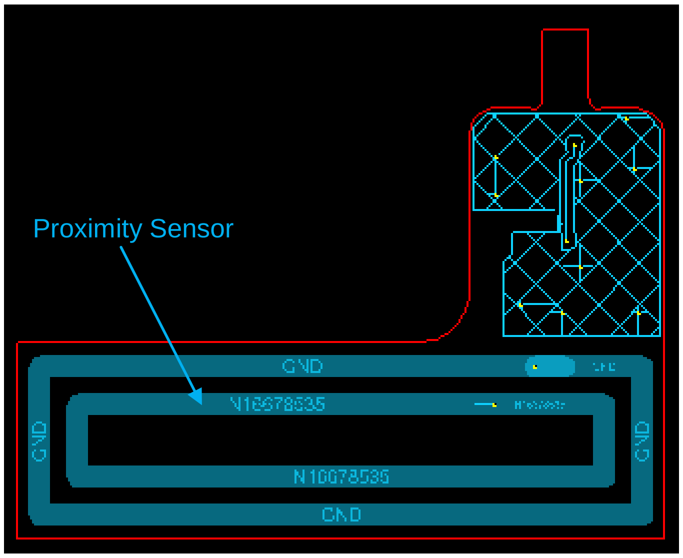
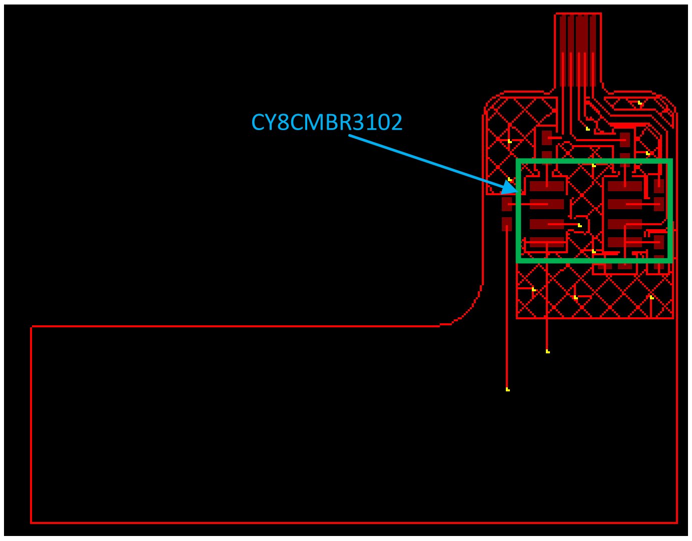


Figure 4-20. Proximity Sensor on FPC – Bottom Layer



5. Configuring CY8CMBR3xxx

CY8CMBR3xxx is an I^{2}C-configurable CapSense controller. This controller provides various features and can be easily configured using EZ-Click. EZ-Click is a simple, intuitive, graphical user interface tool that allows you to easily configure and debug the CY8CMBR3xxx controller. This section explains the various configurations supported in the CY8CMBR3xxx family and how to configure them.

5.1 Configurations in CY8CMBR3xxx

The configurations supported in CY8CMBR3xxx controller can be divided into the following four categories:

1. Sensor configuration
2. GPO configuration
3. Buzzer configuration
4. Global device configuration

5.1.1 Sensor Configuration

5.1.1.1 *Sensitivity Control*

The sensitivity parameter is used to increase or decrease the strength of sensor signal (Difference count). A lower value of sensitivity (100 fF) setting leads to a stronger signal from the sensor, but increases the response time and average power consumption. The different sensitivity settings available are 100 fF, 200 fF, 300 fF and 400 fF. The sensitivity parameter can be configured for each button sensor, guard sensor, and slider group. The sensitivity parameter is not applicable for proximity sensors.

The following factors affect the sensor sensitivity:

1. Overlay thickness: Thicker overlay requires lower value of sensitivity setting.
2. System noise: As system noise increases, sensitivity needs to be lower to avoid false trigger of sensors.
3. Form factor of the design: A relatively large sensor size requires higher value of sensitivity. Sensors with smaller size require lower value of sensitivity.
4. Power consumption: Power consumption increases for lower values of sensitivity setting. For low power consumption, the sensitivity parameter should be high.

   Power consumption decreases in the order 100 fF > 200 fF > 300 fF > 400 fF.

The sensitivity parameter can be set in the “CapSense sensor Configuration” tab in EZ-Click. “Refer to the CapSense Performance Tuning section to understand how to set the sensitivity parameter.

5.1.1.2 *Proximity Resolution*

The proximity distance depends on the proximity resolution parameter. Higher proximity resolution results in higher proximity distance. The resolution parameter should be specified for each proximity sensor. This parameter can range from 12 to 16-bit. The proximity resolution parameter can be set in the “CapSense sensor Configuration” tab in EZ-Click. Refer to the CapSense Performance Tuning section for details on how to set this parameter.

5.1.1.3 *Slider Resolution*

The resolution of the slider indicates the number of unique positions that the controller can resolve. A slider with higher resolution can resolve more number of positions. This parameter is valid only for the CY8CMBR3106S controller. CY8CMBR3106S supports up to two sliders: the SLD1x group and SLD2x group. The resolution parameter for each slider group should be specified. However, if both the sliders are combined in to one single slider, specify only one resolution. The value of this parameter can range from 1 to 254. The slider resolution parameter can be set in the “CapSense sensor Configuration” tab in EZ-Click.

5.1.1.4 *Electromagnetic Compatibility (EMC)*

The EMC feature determines the device's immunity to external, radiated, and conducted noise such as audio-frequency noise from power amplifiers, radio-frequency noise from wireless transmitters, ESD, and power-line surges. For a system in a high-noise environment, enable the EMC feature. Power consumption and response time increase when the EMC feature is enabled.

For designs based on CY8CMBR3106S, EMC feature is applicable only for sensors CS0/PS0, CS1/PS1 and CS2 to CS5. All the slider segments and buttons from CS11-CS15 work without EMC.

For designs based on CY8CMBR3116, EMC feature is applicable only for sensors CS0/PS0, CS1/PS1 and CS2 to CS9.

Disable EMC feature in the following cases:

- If any button from CS10 to CS15 is enabled in CY8CMBR3116 controller.
- If filters are enabled*(In designs based on CY8CMBR3106S only)*
- If your design will operate in a low-noise environment
- If the buzzer is enabled

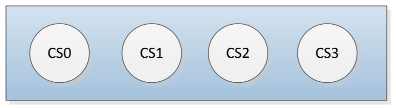
The EMC feature can be enabled in the "Global Configuration" tab in EZ-Click.

5.1.1.5 *Flanking Sensor Suppression (FSS)*

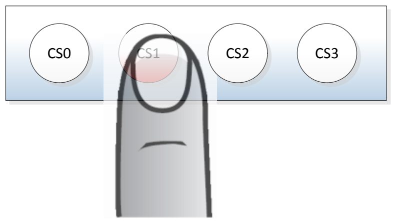
The FSS feature distinguishes among sensor touches from closely-spaced buttons, thus eliminating false touches. It ensures that the system recognizes only the first button touched when multiple sensors are touched. FSS ensures that only one button is reported as ON at anytime, as Figure 5-2 shows. If a finger contacts multiple buttons, only the first one to sense a TOUCH state will be reported as ON. If more than one button is touched at the same time i.e. if multiple buttons are touched simultaneously, then the sensor with lower number is reported as ON.

The FSS feature is only applicable to buttons, and can be enabled or disabled for each button in "CapSense sensor Configuration" tab in EZ-Click.

Figure 5-1. FSS When Only One Button Is Touched

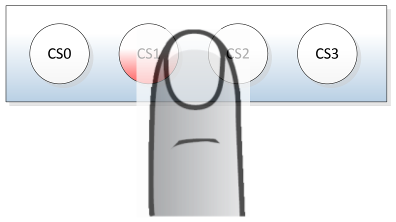


No button is ON prior to the touch

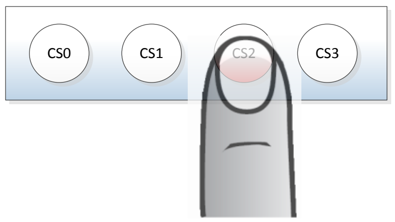


CS1 is reported as ON upon touch

Figure 5-2. FSS When Multiple Buttons are Touched With One Button ON Previously



CS1 is reported as ON when both CS1 and CS2 is touched



CS2 is reported as ON when only CS2 is touched

5.1.1.6 *Firmware filters*

To reduce the noise in sensor raw counts, the CY8CMBR3xxx controller supports the following filters:

- Median Filter
- IIR Filter
- Advanced Low-Pass (ALP) Filter

The Median and IIR filter is applicable only to buttons, sliders, and the guard sensor. The ALP filter is applicable only to proximity sensors.

For designs based on CY8CMBR3106S, note the following considerations:

- ALP filter is not supported
- If EMC feature is enabled, disable the Median and IIR filter

5.1.1.6.1 Median Filter

The median filter is a nonlinear filter that computes the median value from a buffer of size *N*. This filter removes the spike noise from the sensor raw counts. The median filter implemented in CY8CMBR3xxx controller is a third-order moving median filter. Refer to the CapSense Performance Tuning section to know when to enable this filter.

If the median filter is enabled, the Automatic Threshold feature should be disabled and the Finger Threshold parameter should be manually specified.

5.1.1.6.2 Infinite Impulse Response (IIR) filter

The IIR filter produces a step response similar to RC filters. This filter attenuates high-frequency white noise from sensor raw counts. Refer to the CapSense Performance Tuning section to know when to enable this filter.

When both the median and IIR filter are enabled, the median filter is applied first on the raw counts, followed by the IIR filter.

5.1.1.6.3 Advance Low-Pass (ALP) Filter

The ALP filter is used in attenuating the noise in proximity sensor raw counts. To achieve higher proximity distance, the proximity sensor requires higher resolution; however, a higher resolution setting results in increased noise in the raw counts. To attenuate this high noise and achieve an SNR greater than 5:1, enable the ALP filter. Refer to the Tuning a Proximity Sensor section to know when to enable the ALP filter and how to tune it when it is enabled.

5.1.1.7 *Automatic Threshold*

The Automatic threshold feature dynamically sets all the threshold parameters for button sensors, depending on the noise in the environment. For a variable-noise environment, enable this feature. This feature is applicable only to button sensors.

Consider the following on the automatic threshold feature:

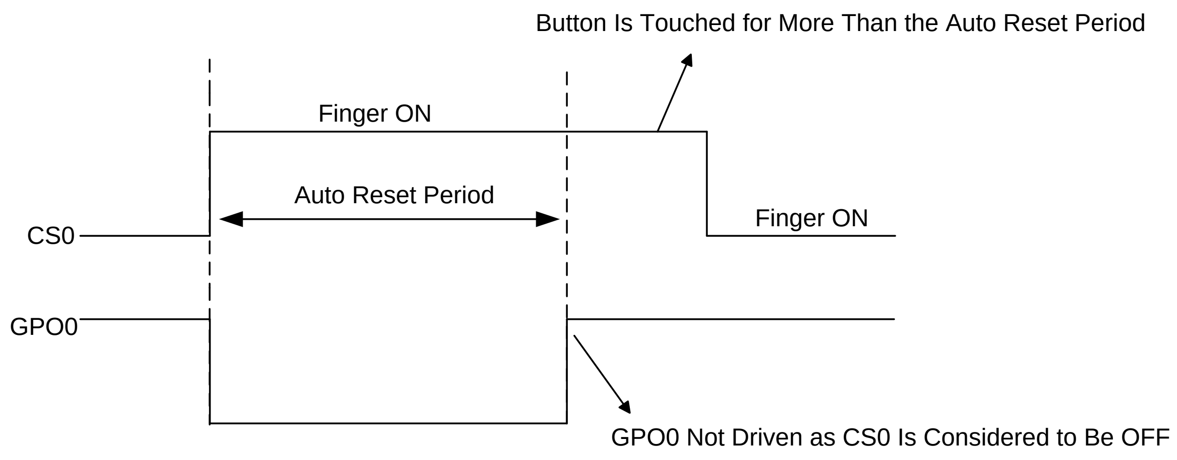
- If EMC feature is enabled, automatic threshold feature will be disabled. In this case, manually set the finger threshold parameter.
- If this feature is disabled, set only the finger threshold parameter. All other threshold parameters are automatically set based on the finger threshold parameter.
- If the median filter is enabled, disable the automatic threshold feature and manually set the finger threshold parameter.

5.1.1.8 *Sensor Auto-Reset Time*

The Sensor Auto-Reset time determines the maximum time a sensor is considered to be ON when the sensors are activated. The sensor will be turned OFF after the auto-reset period, as Figure 5-3 shows. This feature prevents a sensor from getting stuck ON in situations such as a metal object placed too close to it.

There are two sets of auto-reset parameters: auto-reset and proximity auto-reset. The auto-reset parameter is applicable to buttons and sliders. The proximity auto-reset is applicable to proximity sensors. Auto-reset is not applicable to guard sensors. The auto-reset period can be disabled, or set to 5 or 20 seconds.

Figure 5-3. Sensor Auto Reset


Button Is Touched for More Than the Auto Reset Period
Finger ON
Auto Reset Period
Finger ON
CS0
GPO0
GPO0 Not Driven as CS0 Is Considered to Be OFF

5.1.1.9 *Debounce*

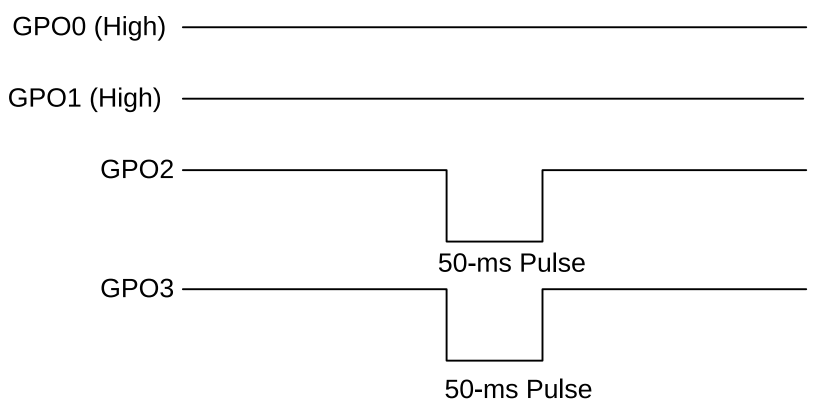
The debounce feature avoids false triggering of sensors due to noise spikes or system glitches by specifying the minimum time a sensor has to be touched for a valid ON status.

The debounce value can vary depending on the sensor function. For example, the power button should have a long debounce time to avoid inadvertently switching the system ON or OFF. Shorter debounce times speed up the device's response to a sensor touch or proximity events. The debounce parameter is applicable for all types of sensors except for slider sensors and can range from 1 to 15. Set this parameter depending on the response time requirement. See the Estimating the Response Time section for more details.

5.1.1.10 *System Diagnostics*

System diagnostics is a built-in power-on self-test (BIST) mechanism. When enabled, it performs several tests at power-on reset (POR) or after software rest, which are useful in production testing. If any sensor is detected faulty, it will be disabled and a 50-ms pulse will be sent out on the corresponding GPO (if GPO is enabled) during power-up, as Figure 5-4 shows. The System Diagnostics status is also updated in the register map so that the host can read the test results through the I^{2}C interface. Refer to the CY8CMBR3xxx Registers TRM for more details.

Figure 5-4. Example Showing CS0, CS1 Passing the BIST and CS2, CS3 Failing



The following tests are performed during power-up:

1. Sensor shorted to Ground: If any sensor is found to be shorted to ground, it is disabled.
2. Sensor shorted to VDD: If any sensor is found to be shorted to VDD, it is disabled.
3. Sensor-to-sensor short: If two or more sensors are found to be shorted to each other, all of these sensors are disabled.
4. Improper value of C_{MOD}: Recommended value of C_{MOD} is 2.2 nF ±10%. If the value of C_{MOD} is found to be less than 1 nF or greater than 4 nF, all sensors are disabled and 50 ms pulse is sent out on all GPOs.
5. Button C_P > 45 pF: If the sensor C_P is greater than 45 pF, then it is disabled. The C_P estimated by CY8CMBR3xxx has an error of ±2 pF. Therefore, the sensor may be disabled if its C_P is in the range of 43-47 pF.
6. If shield is shorted to $V_{DD,}$ Ground, or a sensor, all sensors will be disabled and a 50 ms pulse will be sent out on all the enabled GPOs.
7. If any slider segment fails the above tests, the entire slider will be disabled.

If system diagnostics is enabled, the boot-up time of the CY8CMBR3xxx controller increases. Refer to the System Specifications section in the CY8CMBR3xxx datasheet for more details.

Note: CY8CMBR3106S does not support GPOs; therefore, read the system diagnostics results from the register map using I^2C interface.

5.1.1.11 *Shield and Guard Sensor*

Shield and guard sensor are required for water-tolerant CapSense design. If your design has shield electrode, select the “Enable shield” option in the “Global configuration” tab of the EZ-Click. This selection allows the controller to drive the shield signal on the SH pin.

If your design has guard sensors, select the “Enable Water Tolerance” option in the “Global configuration” tab of the EZ-Click. This selection allows the controller to configure the pin as guard sensor.

5.1.2 GPO Configuration

The CY8CMBR3xxx controller supports up to eight GPOs to drive LEDs or to drive external resistive network to form a basic D/A converter. A GPO can output a PWM signal or a DC voltage level depending on the configuration. Since the GPO pins are multiplexed with the CapSense sensor pins, specify whether a CY8CMBR3xxx pin is a CapSense pin or a GPO pin in EZ-Click.

5.1.2.1 *GPO Drive Mode*

The GPOs in CY8CMBR3xxx support two drive modes: open-drain low and strong-drive mode. The open-drain low mode is equivalent to a normally opened (n/o) switch. When the sensor is inactive, the corresponding GPO will be in the HI-Z state; when it is active, the GPO is pulled LOW. This drive mode is useful for driving an external resistive network to perform a D/A conversion. The strong-drive mode can be used for driving LEDs.

The GPO drive mode is global and applies to all the enabled GPOs.

5.1.2.2 *GPO Logic Level*

CY8CMBR3xxx allows the user to configure the logic level (Active HIGH or Active LOW) of the GPO pin. This feature provides flexibility in controlling the output voltage of GPOs based on the sensor status, as Table 5-1 shows. This feature is global and applies to all the enabled GPO pins. If the drive mode is set to open-drain low drive mode then the Table 5-1 is applicable only when the pin is externally pulled to V_{DD}.

Table 5-1. GPO Logic Level

GPO Logic Level	**Sensor Status**	**Output Voltage on GPO**
Active HIGH	ON	V_{DD}
	OFF	GND
Active LOW	ON	GND
	OFF	V_{DD}

5.1.2.3 *PWM Output on GPO*

CY8CMBR3xxx provides a PWM output on the GPO pins. The PWM signal is useful for controlling the brightness of LEDs. To enable PWM output on GPOs, specify the active-state duty cycle and inactive-state duty cycle percentage in the “Global configuration” tab in EZ-Click. Active duty cycle of 100% and inactive duty cycle of 0% results in a DC output on the GPO.

The PWM output feature is global and applies to all enabled GPOs. The frequency of the PWM signal is 106.6 Hz. The PWM duty cycle can be configured for each GPO with a step size of 6.67%.

5.1.2.4 *GPO Host Control*

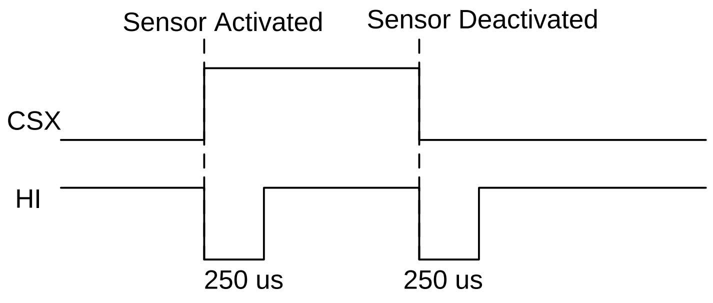
In CY8CMBR3xxx, each GPO (GPO0-GPO7) is logically linked to the CapSense pins (CS0-CS7). When a sensor is activated, the corresponding GPO will be automatically turned ON. However, if the host processor wants to control the GPO pins, the GPO host control feature should be enabled. This feature allows the host processor to control the GPO pins by writing to the GPO_OUTPUT_STATE register. Refer to CY8CMBR3xxx Registers TRM for more details.

The delay between the host writing the command and the CY8CMBR3xxx controller responding to these commands is equal to one Scan Period when the controller is operating in Look-for-Touch Mode and Look-for-Proximity Mode. If the controller is operating in active mode, then the delay depends on the total scan time of all sensors.

5.1.2.5 *Host Interrupt*

The host interrupt feature generates an active low pulse signal with duration of 250 µs on the HI pin to the host processor whenever the sensor status or slider position changes, as Figure 5-5 shows. To enable this feature specify the Host Interrupt pin in the EZ-Click. The host interrupt pin has open-drain low-drive mode configuration and requires an external pull-up resistor for proper operation.

Figure 5-5. Host Interrupt Line when CSx Button is Touched



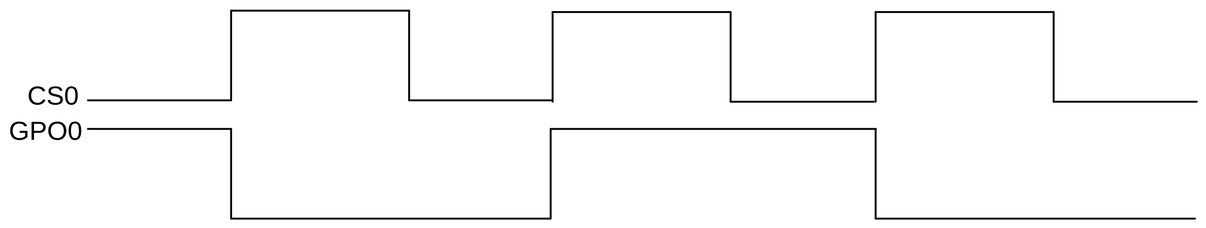
5.1.2.6 *Toggle*

When the Toggle feature is enabled, the state of GPO pins changes on every rising edge of the button and proximity sensor status. This feature implements the mechanical push button switch behavior in CapSense controller. The toggle configuration is shown in Figure 5-6. The toggle feature can be enabled or disabled for each GPO pin.

Take into account the following considerations for using the toggle feature:

- The toggle and LED ON time features are mutually exclusive. If both the features are enabled, the toggle feature takes higher priority and so the LED ON time feature will be disabled.
- If toggle feature is enabled and any GPO is turned ON, the device will not enter the Look-for-Proximity Mode. Disable toggle feature if your design requires wake-on-approach feature.

Figure 5-6. Example of Toggle Feature

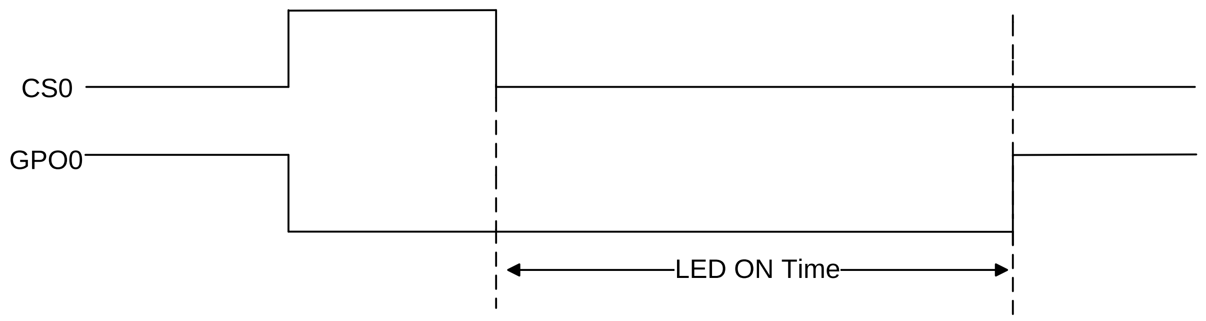


5.1.2.7 *LED ON Time*

The LED ON time specifies the duration for which the GPO pin is driven LOW or HIGH after the corresponding sensor is released, as shown in Figure 5-7. The LED ON time feature can be enabled or disabled on each GPO pin. LED ON time is global for all GPOs and can range from 0 to 2000 ms, with a resolution of 20 ms.

The toggle and LED ON time features are mutually exclusive. If both features are enabled, the toggle feature takes the higher priority and so the LED ON time feature will be disabled.

Figure 5-7. LED ON Time



5.1.2.8 *Analog Voltage Output*

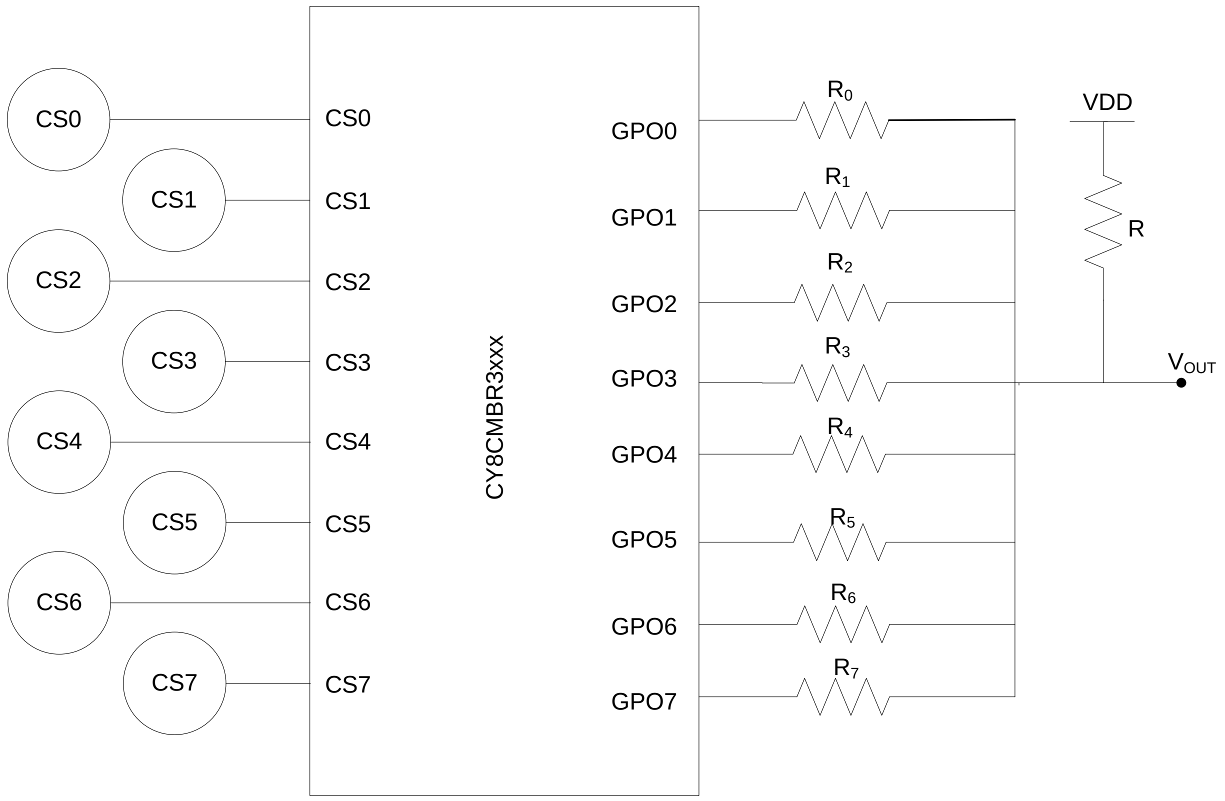
The analog voltage output feature uses a resistor network to indicate the sensor status as an analog voltage to the host, as Figure 5-8 shows. In this configuration, the GPO drive mode should be set to open-drain LOW-drive mode. When the sensor is touched, the corresponding GPO is driven to a logic LOW signal and a voltage divider is formed at V_{OUT}. When the sensor is released, the corresponding GPO is in HI-Z state and the voltage V_{OUT} will be at V_{DD}. The FSS feature can be enabled so that only one button is reported ON at a time.

The analog voltage V_{OUT} is given by:

$$Vout = \frac{VDD \times Rn}{R + Rn} \qquad \text{Equation 3}$$

Where: R is the resistance between VDD and V_{OUT}
Rn is the effective resistance between V_{OUT} and Ground

Figure 5-8. Analog Voltage Output Using GPO and Resistor Network



5.1.3 Buzzer Configuration

5.1.3.1 *Buzzer Output*

CY8CMBR3xxx supports a single-input Piezo-buzzer. The buzzer is driven by a PWM signal; its frequency is configurable. To enable the buzzer, select the buzzer pin in EZ-Click.

The CY8CMBR3xxx supports buzzer frequencies of 1.0, 1.1, 1.3, 1.6, 2.0, 2.6, and 4.0 kHz to meet different Piezo-buzzer drive requirements and to provide different tones. The duty cycle of buzzer output is fixed at 50%.

5.1.3.2 *Buzzer ON Time*

The Buzzer ON-Time feature allows the user to specify the duration for which the buzzer output should be active when the sensor is activated, as Figure 5-9 shows. The buzzer signal output is driven for the configured time and does not depend on the sensor touch time. The output goes to the idle state after the Buzzer ON-Time elapses, even if the sensor is active.

The buzzer signal output does not restart if the same sensor or any other sensor is touched before the Buzzer ON-Time elapses, as Figure 5-10 and Figure 5-11 show. The Buzzer ON-Time can range from 100 ms to 12.7 s with a resolution of 100 ms.

Figure 5-9. Buzzer Activation on Touch Event

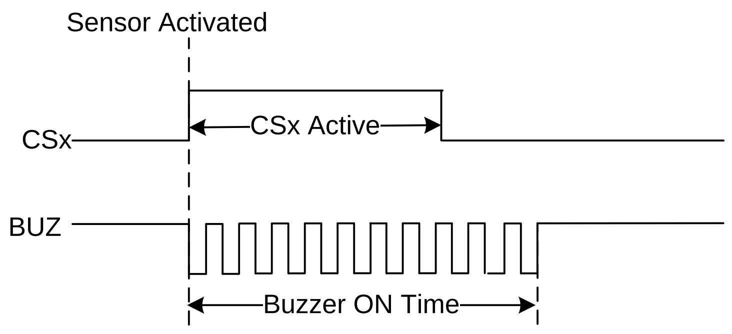


Figure 5-10. Buzzer Operation with Consecutive Touches of the Same Sensor

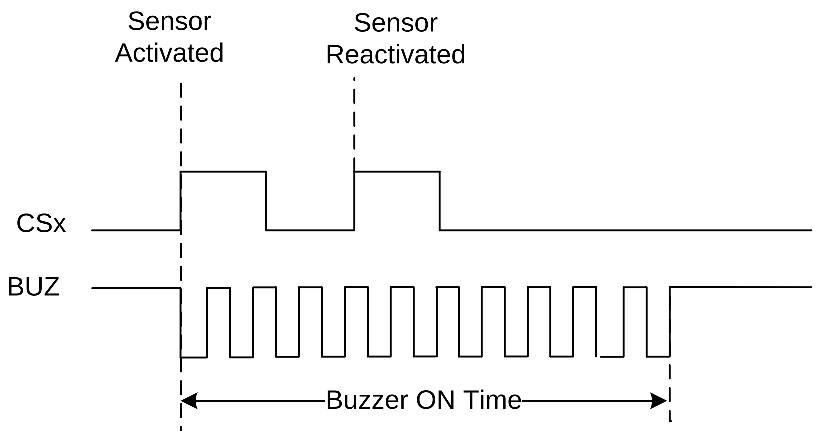
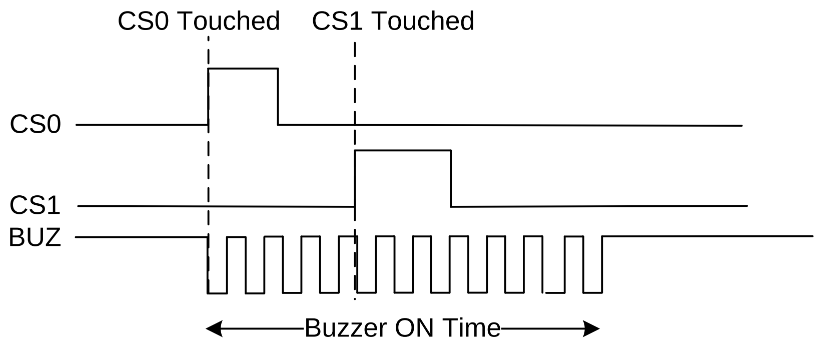


Figure 5-11. Buzzer Operation When Multiple Sensors Are Activated



5.1.4 Device Configuration

5.1.4.1 *Supply Voltage*

The supply voltage of the CY8CMBR3xxx controller should be specified in EZ-Click for proper operation. If the operating voltage is in the range of 1.71 to 1.89 V, select the 1.8(±5%) V option; otherwise select the 1.8-5.5 V option.

5.1.4.2 *I^2C Address*

The CY8CMBR3xxx controller communicates to the host processor through the I^2C interface. In a typical I^2C communication, there will be more than one slave device on the I^2C bus. To avoid conflicts in the I^2C address among the slave devices, CY8CMBR3xxx provides an option to specify the I^2C address of the controller. The I^2C address is the 7-bit value and can range from 8 (0x08) to 119 (0x77).

5.1.4.3 *Scan Period*

The scan period parameter specifies the amount of time between successive sensor scans in Look-for-Touch Mode and Look-for-Proximity Mode. This parameter can range from 20 to 500 ms with a resolution of 20 ms.

The response time and power consumption of the controller depends on the scan period. See the Low-Power Design Considerations section for more details.

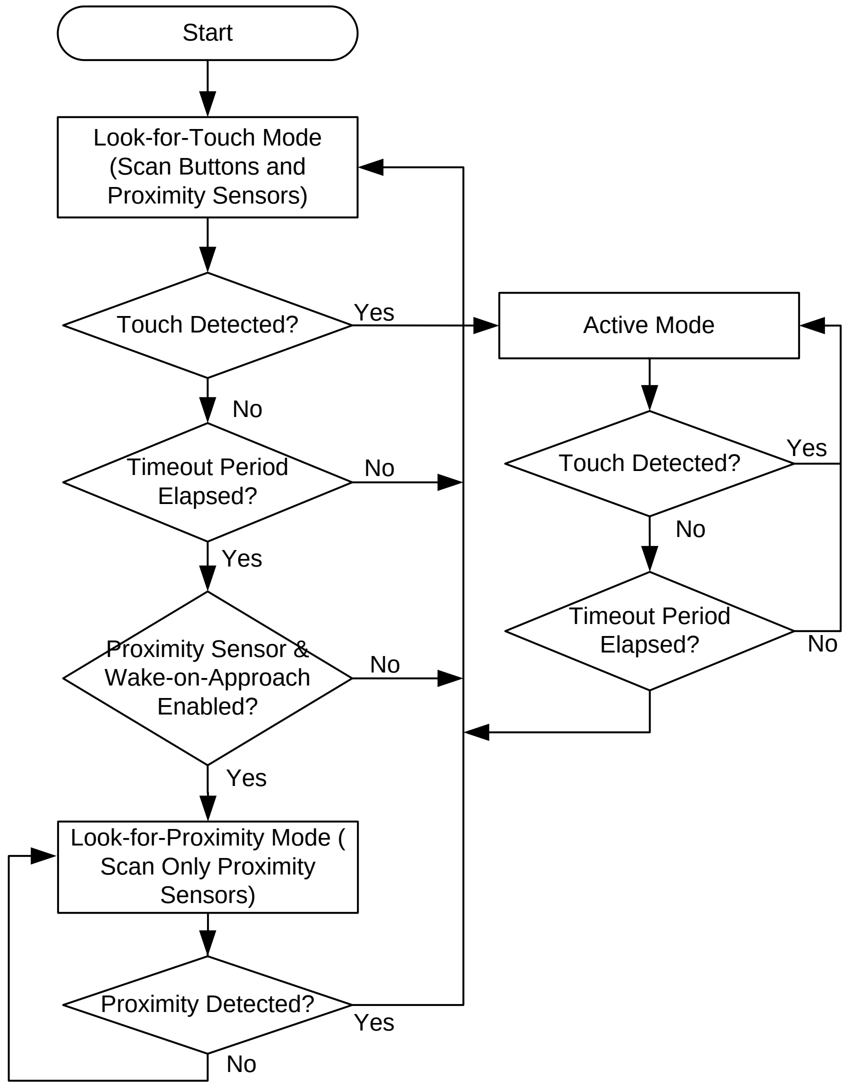
5.1.4.4 *State Timeout*

The State Timeout interval decides the time taken by the device to transition from one operating mode to another when the sensors are not touched. This parameter affects the response time of the sensors for consecutive touches. This parameter should be set based on the design requirements. This allows the controller to stay in the active mode and provide a fast response to consecutive touches. This parameter can range from 0 to 63 s with a resolution of 1 s.

5.1.4.5 *Wake-on-Approach*

To reduce power consumption, CapSense designs use the wake-on-approach feature. This feature allows the device to enter the Look-for-Proximity Mode when proximity sensors are enabled. In the look-for-proximity mode, only proximity sensors are scanned; when proximity is detected, the controller enters the Look-for-Touch Mode in which all the sensors are scanned, as shown in Figure 5-12. See the Low-Power Design Considerations section for more details.

Figure 5-12. Transition From Look-for-Touch Mode to Look-for-Proximity Mode


Start
Look-for-Touch Mode (Scan Buttons and Proximity Sensors)
Touch Detected?
Yes
No
Active Mode
Timeout Period Elapsed?
No
Yes
Touch Detected?
Yes
No
Timeout Period Elapsed?
No
Proximity Sensor & Wake-on-Approach Enabled?
No
Yes
Look-for-Proximity Mode (Scan Only Proximity Sensors)
Proximity Detected?
Yes
No

5.2 Configuring CY8CMBR3xxx

The CY8CMBR3xxx family is a register-configurable CapSense controller. This controller has 128 bytes of configuration registers which can be configured via I^{2}C interface. The configuration data can be saved to nonvolatile memory so that controller retains the configuration data even when it is powered-off.

For more information on the CY8CMBR3xxx registers, refer to the CY8CMBR3xxx Registers TRM.

The CY8CMBR3xxx configuration registers are configured via I^{2}C interface using one of the following methods:

1. EZ-Click 2.0
2. Third-party Programmer
3. Host APIs
4. Bridge Control Panel

5.2.1 Configuring CY8CMBR3xxx Using EZ-Click

EZ-Click is a simple and intuitive graphical user interface (GUI) used to configure the CY8CMBR3xxx CapSense controller. It takes all the required parameters, and configures the device via I^2C interface.

This section provides a quick introduction to EZ-Click. Refer to the EZ-Click user guide for details on how to configure the CY8CMBR3xxx controller.

EZ-Click provides the following features:

- A Graphical User Interface (GUI) to configure the CY8CMBR3xxx controller.
- Allows tuning the sensor parameters and viewing the sensor debug data in real time.
- Supports production-line testing and displays system diagnostics results and the CapSense sensor SNR.
- Allows to save the configuration and use it on multiple samples.
- Generates a header file which consists of an array with 128 bytes of configuration data to configure CY8CMBR3xxx controller using Host APIs, as Figure 5-15 shows. For more details, go to Section 5.2.3
- Generates hex file of your configuration to configure the device using third-party programming tools. For more details, refer to section 5.2.2
- Generates the configuration file, including the required I^2C instructions to configure the device using the Bridge Control Panel, as Figure 5-22 shows. For more details, refer to section 5.2.4

EZ-Click has five tabs, as Figure 5-14 shows:

- Start Page: This page shows the steps to create a new project, generate configuration files, and configure the MBR family of controllers.
- CapSense sensor configuration: In this tab, the number of sensors can be selected and various parameters and features can be set for each sensor.
- Global configuration: In this tab, the GPOs can be enabled and the global parameters can be specified.
- CapSense output: In this tab, the sensor debug data can be monitored for debugging purpose.
- System diagnostics: In this tab, the system diagnostics results can be viewed for each sensor.

Note: The “CapSense sensor configuration”, “Global configuration”, CapSense output and System diagnostics tab can be accessed only if a new project is created or an existing project is opened.

Figure 5-13. Configuring CY8CMBR3xxx Using Various Files Generated by EZ-Click

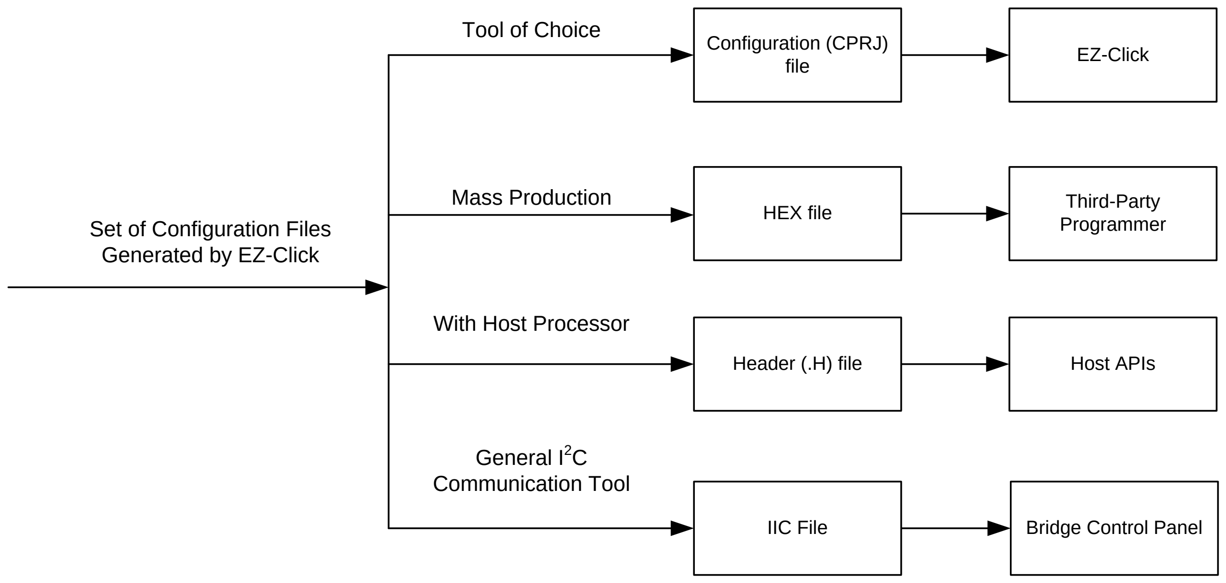
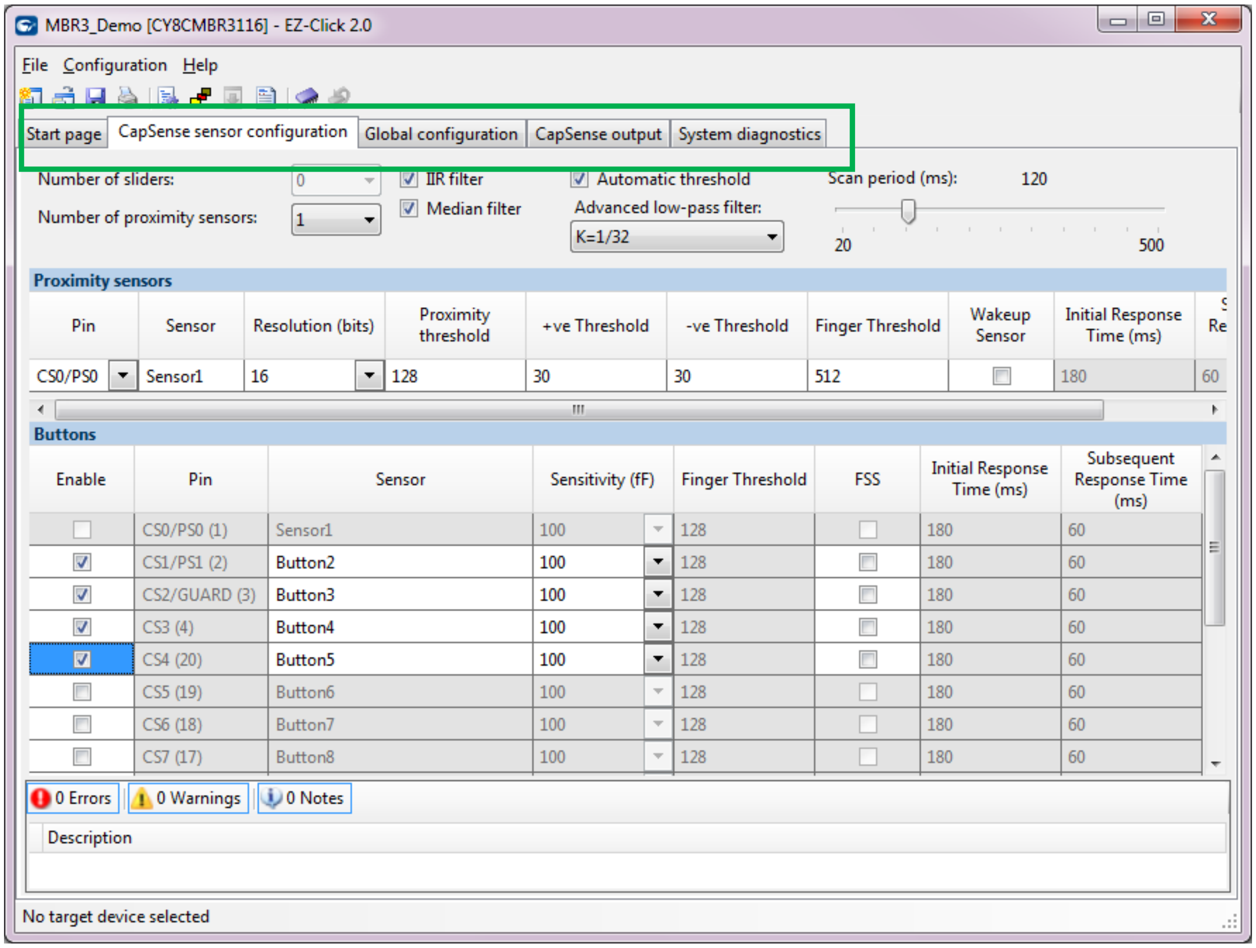


Figure 5-14. EZ-Click Customizer Tool



Number of sliders: 0

Number of proximity sensors: 1

☑ IIR filter

☑ Median filter

☑ Automatic threshold

Advanced low-pass filter: K=1/32

Scan period (ms): 120 (20–500)

Proximity sensors

Pin	Sensor	Resolution (bits)	Proximity threshold	+ve Threshold	-ve Threshold	Finger Threshold	Wakeup Sensor	Initial Response Time (ms)	Re
CS0/PS0	Sensor1	16	128	30	30	512	☐	180	60

Buttons

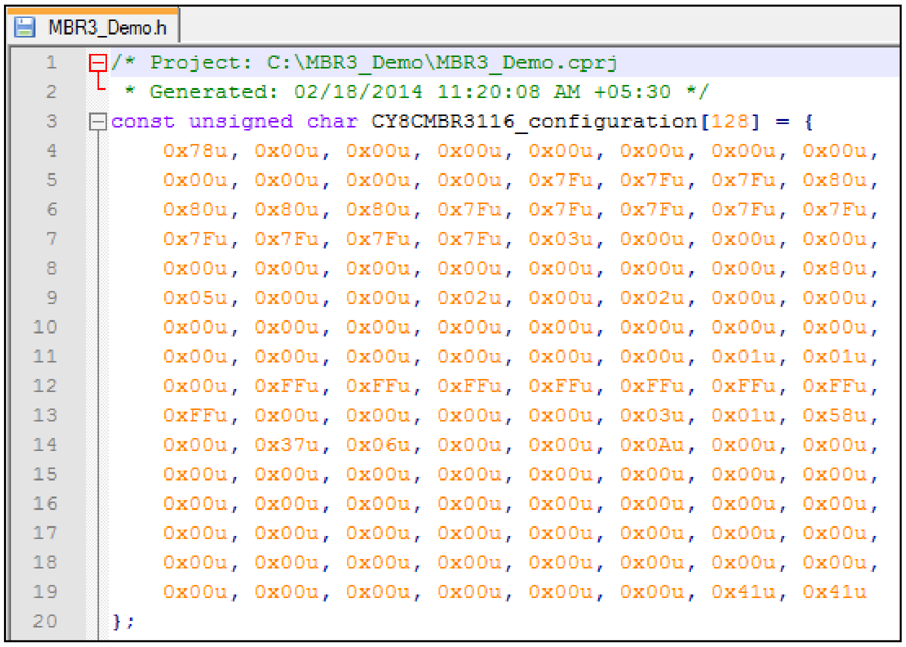
Enable	Pin	Sensor	Sensitivity (fF)	Finger Threshold	FSS	Initial Response Time (ms)	Subsequent Response Time (ms)
☐	CS0/PS0 (1)	Sensor1	100	128	☐	180	60
☑	CS1/PS1 (2)	Button2	100	128	☐	180	60
☑	CS2/GUARD (3)	Button3	100	128	☐	180	60
☑	CS3 (4)	Button4	100	128	☐	180	60
☑	CS4 (20)	Button5	100	128	☐	180	60
☐	CS5 (19)	Button6	100	128	☐	180	60
☐	CS6 (18)	Button7	100	128	☐	180	60
☐	CS7 (17)	Button8	100	128	☐	180	60

0 Errors 0 Warnings 0 Notes

Description

No target device selected

Figure 5-15. C Header File Generated by the EZ-Click Customizer Tool



```
/* Project: C:\MBR3_Demo\MBR3_Demo.cprj
 * Generated: 02/18/2014 11:20:08 AM +05:30 */
const unsigned char CY8CMBR3116_configuration[128] = {
    0x78u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u,
    0x00u, 0x00u, 0x00u, 0x00u, 0x7Fu, 0x7Fu, 0x7Fu, 0x80u,
    0x80u, 0x80u, 0x80u, 0x7Fu, 0x7Fu, 0x7Fu, 0x7Fu, 0x7Fu,
    0x7Fu, 0x7Fu, 0x7Fu, 0x7Fu, 0x03u, 0x00u, 0x00u, 0x00u,
    0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x80u,
    0x05u, 0x00u, 0x00u, 0x02u, 0x00u, 0x02u, 0x00u, 0x00u,
    0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u,
    0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x01u, 0x01u,
    0x00u, 0xFFu, 0xFFu, 0xFFu, 0xFFu, 0xFFu, 0xFFu, 0xFFu,
    0xFFu, 0x00u, 0x00u, 0x00u, 0x00u, 0x03u, 0x01u, 0x58u,
    0x00u, 0x37u, 0x06u, 0x00u, 0x00u, 0x0Au, 0x00u, 0x00u,
    0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u,
    0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u,
    0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u,
    0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u,
    0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x00u, 0x41u, 0x41u
};
```

5.2.2 Configuring CY8CMBR3xxx Using a Third-Party Programmer

To configure large number of devices rapidly during mass production, Cypress recommends using a third-party programmer from RPM Systems Corporation. To configure the CY8CMBR3xxx controller using the third-party programmer, use the hex file of the configuration generated by EZ-Click. Contact RPM Systems Corporation for further information.

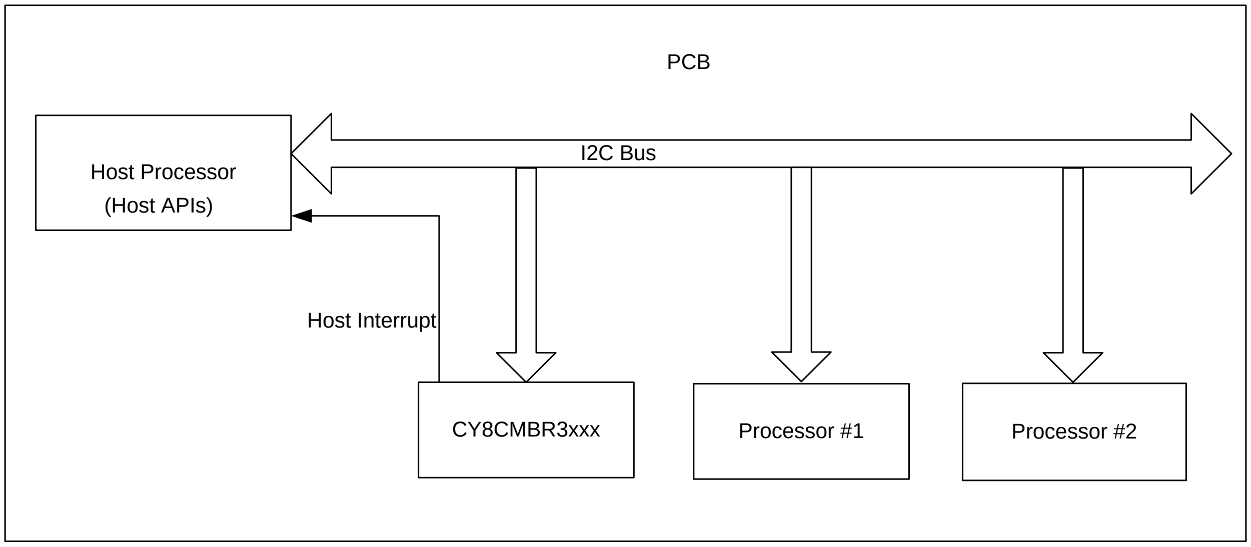
For information on the CY8CMBR3xxx family programming specifications refer to the CY8CMBR3xxx Device Programming Specifications.

5.2.3 Configuring CY8CMBR3xxx Using Host APIs

Figure 5-16 shows a system where the host processor communicates via I^{2}C interface with the CY8CMBR3xxx controller along with few other processors on the same PCB. The host can read back the sensor status from the CY8CMBR3xxx controller during run-time, tune its operation if required, and also re-configure it to suit a different requirement.

To configure the CY8CMBR3xxx controller on-board using a host processor, Cypress provides a set of library files called “Host APIs” which can be integrated into the host processor firmware. This section provides the description of Host APIs and explains how to use them to configure the CY8CMBR3xxx Controller.

Figure 5-16. System Demonstrating Host API Usage



5.2.3.1 *Host APIs Overview*

Host APIs are a set of C-style functions provided by Cypress to enable the host processor to interact with the CY8CMBR3xxx controller, directly via I^{2}C interface.

These APIs can be used to:

1. Configure the CY8CMBR3xxx controller
2. Issue I^{2}C commands to the CY8CMBR3xxx controller
3. Read information from the CY8CMBR3xxx register map

5.2.3.2 *Host API Description and Usage*

Host APIs are divided into two sections: High-Level APIs and Low-Level APIs.

5.2.3.2.1 High-Level APIs

High-Level APIs implement the required functionality purely in C-style software, and are in-turn dependent on Low-Level APIs for physical interaction with the CY8CMBR3xxx controller. Table 5-2 lists the High Level APIs and their usage. The API prototypes, parameters, and return values are mentioned in the Appendix.

Table 5-2. High-Level Host APIs

#	API	Description and Usage
1	CY8CMBR3xxx_WriteData()	General purpose API to write data to the device. Use this API to write to one or more registers of the CY8CMBR3xxx controller
2	CY8CMBR3xxx_ReadData()	General purpose API to read data from the CY8CMBR3xxx controller. Use this API to read from one or more registers of the CY8CMBR3xxx controller.
3	CY8CMBR3xxx_WriteDualByte()	API to write to a two-byte register of the CY8CMBR3xxx controller. For example, the 16-bit sensor enable register can be written using this API.
4	CY8CMBR3xxx_ReadDualByte()	API to read from a two-byte register of the CY8CMBR3xxx controller. For example, the 16-bit sensor status register can be read using this API.
5	CY8CMBR3xxx_SendCommand()	API to issue commands to the CY8CMBR3xxx controller, such as to save configuration to nonvolatile memory, reset the CY8CMBR3xxx controller, etc.
6	CY8CMBR3xxx_CheckCommandStatus()	API to check the status of the last command sent to the CY8CMBR3xxx controller. It is recommended to call this API in the host processor before sending a new command to the CY8CMBR3xxx controller.
7	CY8CMBR3xxx_Configure()	API to configure the entire 128 bytes of configuration registers in the CY8CMBR3xxx controller. To use this API, create a configuration in EZ-Click and use the generated header file in the host firmware.
8	CY8CMBR3xxx_CalculateCrc()	API to calculate CRC checksum of a given configuration.
9	CY8CMBR3xxx_VerifyDeviceOnBus()	API to verify that the CY8CMBR3xxx device on the I^{2}C bus is the intended one[8]. Call this API from the host processor to confirm that the right I^{2}C slave device is on the bus.
10	CY8CMBR3xxx_SetDebugDataSensorId()	This API sets the sensor number for which the sensor debug data has to be read from the CY8CMBR3xxx controller.
11	CY8CMBR3xxx_ReadSensorDebugData()	API to read sensor debug data. This API helps in knowing the sensor performance.
12	CY8CMBR3xxx_ReadDiffCounts()	API to read the difference counts of all sensors of the CY8CMBR3xxx controller.
13	CY8CMBR3xxx_ReadSensorStatus()	API to read the status of all sensors of the CY8CMBR3xxx controller. When the CY8CMBR3xxx controller issues a Host Interrupt pulse, call this API to know which sensor is triggered.

5.2.3.2.2 Low-Level APIs

Low-Level APIs are responsible for the physical communication between the host processor and the CY8CMBR3xxx device via I^{2}C interface, and are thus hardware dependent. These APIs support PSoC4 architecture by default, and require to be modified to support specific host processor.

[8] The Host APIs cannot be used to configure different controllers of the CY8CMBR3xxx family present on the same I^{2}C bus.

When the CY8CMBR3xxx controller is in Deep Sleep Mode, the first I^2C transaction will be NACKed. If the CY8CMBR3xxx controller NACKs the I^2C transaction, these Low-Level APIs must retry twice within the next 340 ms for a successful transaction. Refer to the “Host Communication Protocol” in the CY8CMBR3xxx Datasheet. To achieve this either disable all the interrupts in the host processor except for I^2C, or ensure that all pending interrupts complete within 340 ms. If there is a delay of more than 340 ms between two subsequent I^2C transactions, the device might go into Deep Sleep Mode and the host might receive a NACK.

There are three low level APIs – Host_LowLevelWrite(), Host_LowLevelRead(), and Host_LowLevelDelay(). The API prototypes, parameters, and return values are mentioned in the Appendix.

Table 5-3. Low-Level Host APIs

#	API	Description and Usage
1	Host_LowLevelWrite()	API to write to the register map of the CY8CMBR3xxx controller via I^2C interface.
2	Host_LowLevelRead()	API to read data from the register map of the CY8CMBR3xxx controller via I^2C interface.
3	Host_LowLevelDelay()	This API implements a time-delay function to be used by the High-level APIs. The delay period is in milliseconds. This delay is achieved by a code-execution block for the required amount of time.

5.2.3.3 *Host API File Structure*

The files listed in Table 5-4 form the library of Host APIs.

Table 5-4. File Structure for Host APIs

#	File Name	Description
1	CY8CMBR3xxx_Device.h	This file contains the macros to define the various devices in CY8CMBR3xxx family. Also, it defines which device is currently being used for the Host APIs.
2	CY8CMBR3xxx_Registers.h	This file contains the macros to define the offset addresses for all the registers of the CY8CMBR3xxx family. Use these macros to refer to the registers, in place of their addresses directly. Each register’s macro is accessible only if the register is available for the currently used device.
3	CY8CMBR3xxx_CommandsAndConfig.h	This file contains the macros to define the various op-codes of the command register (CTRL_CMD).
4	CY8CMBR3xxx_APIs.h	This file contains the declarations of all the high-level APIs. This file also declares the structure definitions for holding the sensor debug data and sensor status read from the device.
5	CY8CMBR3xxx_CRC.c	This file contains the API to calculate CRC for a given configuration of CY8CMBR3xxx device.
6	CY8CMBR3xxx_APIs.c	This file contains the definitions of all the high-level APIs, except the API to calculate CRC.
7	CY8CMBR3xxx_HostFunctions.h	This file contains the declarations of the host-dependent, low-level APIs.
8	CY8CMBR3xxx_HostFunctions.c	This file contains the definitions of the low-level APIs. Modify the content of these APIs to suit the host processor’s I^2C implementation.

5.2.3.4 *Macros*

There are two macros "CY8CMBR3XXX_DEVICE" and "CY8CMBR3xxx_SYNC_COUNTER_MATCH_RETRY" defined in "CY8CMBR3xxx_Device.h" and "CY8CMBR3xxx_APIs.h" respectively. These two macros need to be modified to define the CY8CMBR3xxx controller and the I^{2}C retry counts in case of sync counter mismatch.

1. CY8CMBR3xxx_DEVICE
   This macro defines the controller accessed by the host. This controller can be one of the different controllers in the CY8CMBR3xxx family, except for CY8CMBR3002 (since this controller does not support I^{2}C communication). The different controllers in CY8CMBR3xxx family are defined in CY8CMBR3xxx_Device.h.

2. CY8CMBR3xxx_SYNC_COUNTER_MATCH_RETRY
   This macro defines the number of times the APIs CY8CMBR3xxx_ReadSensorDebugData() and CY8CMBR3xxx_ReadDiffCounts() retry I^{2}C communication with the CY8CMBR3xxx controller in case the sync counters do not match during a read operation. Typically the read operation will be successful in 2nd attempt if not in the 1st attempt. It is recommended to set a value which is < 10. To know more about sync counters, refer to CY8CMBR3xxx Registers TRM.

5.2.3.5 *Demo Project and its Usage*

To quickly get familiarized with using Host APIs, a demo project is created with the PSoC4 as the host processor. This demo showcases how to use Host APIs to configure the CY8CMBR3116 controller on the CY3280-MBR3 Evaluation Kit using the PSoC4 Pioneer Kit.

The hardware required for this demo is listed below:

- CY3280-MBR3 Evaluation Kit
- CY8CKIT-042 PSoC4 Pioneer kit
- USB A to mini-B cable
- PC/Laptop

The software required for this demo is listed below:

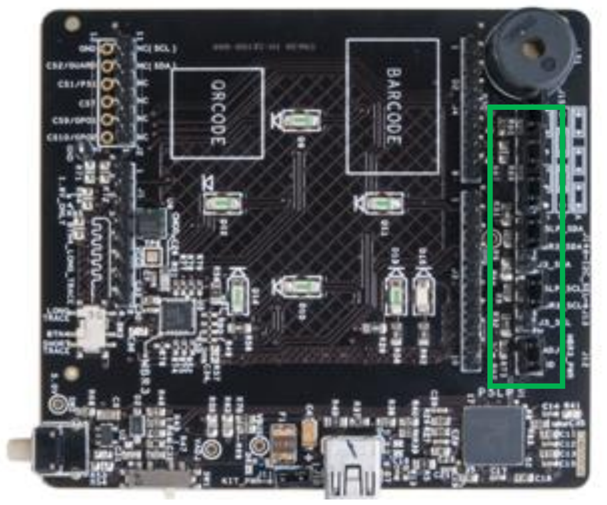
- PSoC Programmer 3.20.0

Note: The kit driver for PSoC4 pioneer kit should already have been installed. Refer to CY8CKIT-042 PSoC 4 Pioneer Kit Guide for details on installing kit driver.

To configure the MBR3 Evaluation Kit using the PSoC4 Pioneer Kit follow the below procedure:

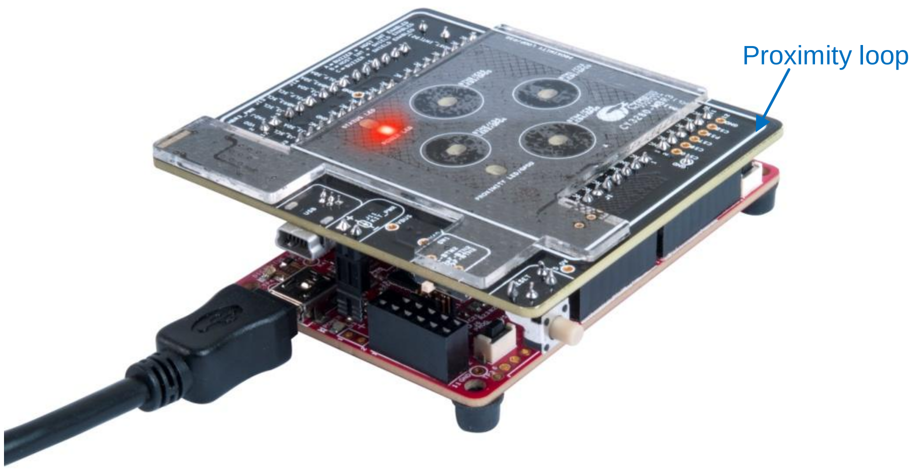
1. Change the jumper position on header J13 on MBR3 Evaluation Kit to connect pins J13-2 and J13-3.
2. Change the jumper position on header J14 on MBR3 Evaluation Kit to connect pins J14-2 and J14-3.
3. Change the jumper position on header J15 on MBR3 Evaluation Kit to position A. This will enable the kit to support Buzzer and Host Interrupt output.

Figure 5-17. Jumper J13, J14 and J15 Location on the MBR3 Evaluation Kit



4. Mount the MBR3 Kit on top of the PSoC4 Pioneer Kit, such that the USB ports of both kits align with each other. When the USB ports are aligned, the J1, J2, J3, and J4 headers on the PSoC 4 Pioneer Kit connect to J1, J2, J3, and J4 headers on the CY3280-MBR3 EVK.
5. Connect the PSoC4 Pioneer Kit to PC via the USB A to mini-B cable, available as part of the MBR3 Evaluation Kit. The power LED (red) of the MBR3 kit glows. The final connection is shown in Figure 5-18. Once the hardware setup is done, the project can be downloaded onto the PSoC4 host

Figure 5-18. MBR3 Kit Mounted on Top of PSoC4 Pioneer Kit



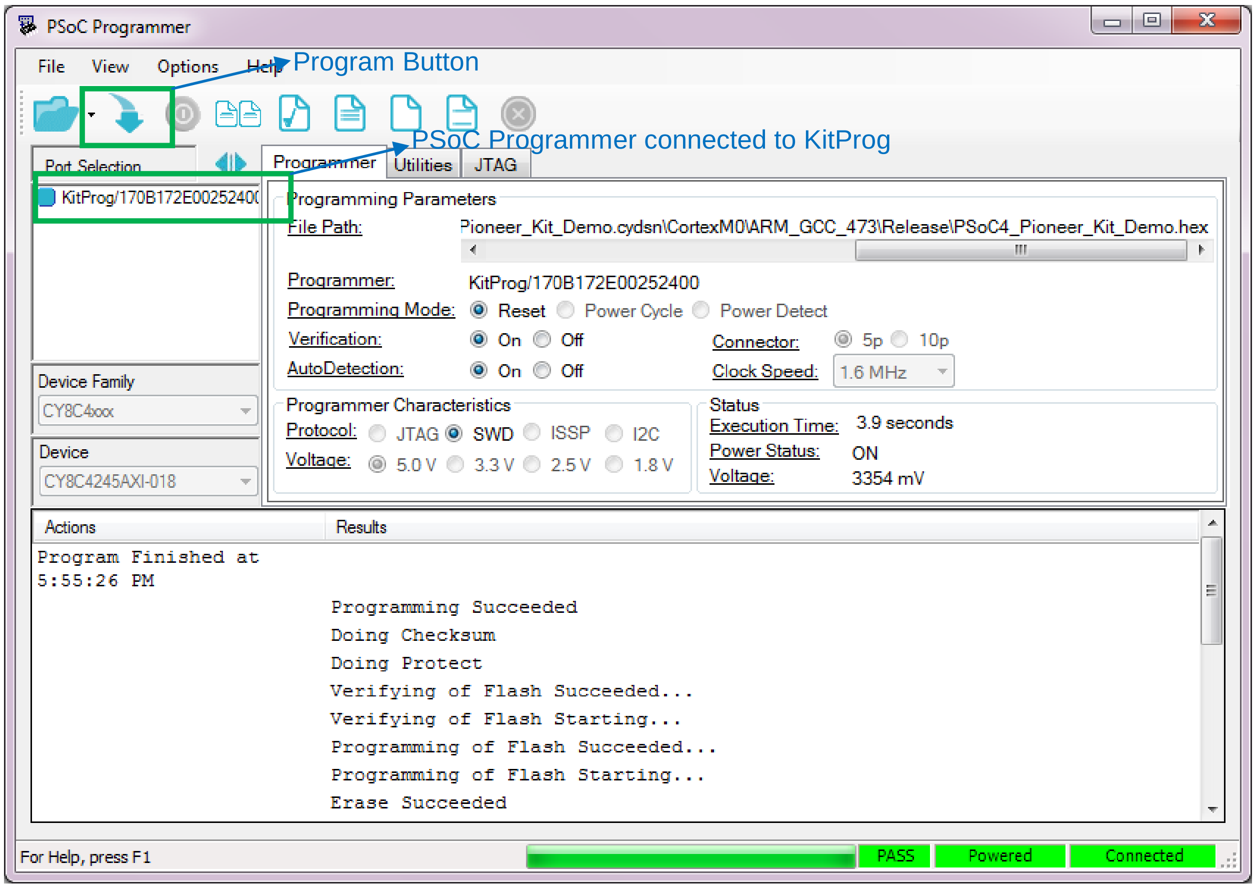
6. Download the “CY8CMBR3xxx_Host_APIs_Demo_Project.zip” project from here and extract the contents from the .zip file.
7. Open PSoC Programmer. It is located at Windows start menu→ All programs →Cypress→PSoC Programmer 3.20.0. If PSoC Programmer is not installed in your PC, download it from PSoC Programmer 3.20.0 and install.
8. In the PSoC Programmer click on File→File Load and navigate to the directory where the “CY8CMBR3xxx_Host APIs_Demo_Project” is extracted.

9. Navigate to CY8CMBR3xxx_Host_APIs_Demo_Project→ PSoC4_Pioneer_Kit_Demo→ PSoC4_Pioneer_Kit_Demo.cydsn→CortexM0→ARM_GCC_473→Release→PSoC4_Pioneer_Kit_Demo.hex and click on open.
10. Make sure that the PSoC Programmer is connected to KitProg as shown in Figure 5-19. Click on Program button to program the PSoC4 Pioneer Kit with the given hex file, as shown in Figure 5-19.
11. Once the PSoC4 Pioneer Kit is programmed, the PSoC4 Pioneer Kit configures the CY8CMBR3116 controller on the MBR3 Evaluation Kit with the demo configuration. If the CY8CMBR3116 controller is successfully configured, the RGB LED D9 on the PSoC4 Pioneer Kit glows Green. If the CY8CMBR3xxx controller is not successfully configured, the RGB LED D9 on the PSoC4 Pioneer Kit glows Red.

    The MBR3 Evaluation Kit is configured for the following:
    - Four CapSense button sensors
    - One Proximity sensor
    - One Proximity LED
    - Buzzer output
    - Host Interrupt output
    - Host controlled GPOs.

    The LEDs in the MBR3 Evaluation Kit is turned ON/OFF by the host processor (PSoC4) whenever the CY8CMBR3116 controller sends a Host Interrupt pulse. When a Host Interrupt is triggered, the host reads the status of all the sensors of the CY8CMBR3116 controller and turns ON the corresponding LED if the sensor status is set to ‘1’.
12. After the PSoC4 host configures the CY8CMBR3116 controller, verify the following features on the MBR3 Evaluation Kit:
    - Proximity: Hover your hand/finger (3-cm distance) over the MBR3 Evaluation kit; the proximity LED blinks once, to indicate proximity detection. Touch the proximity sensor (marked by white rectangle at the edge of the MBR3 Kit); The buzzer beeps for 500 ms and the proximity LED remains ON as long as proximity sensor is touched. When the hand/finger is no longer touching the proximity sensor, the proximity LED turns OFF to indicate that proximity touch is no longer detected. Moving the hand/finger further away results in the proximity LED blinking once more to indicate that the proximity is no longer detected.
    - CapSense buttons: Touch any CapSense button; the corresponding LED turns ON and buzzer beeps for 500 ms.

Figure 5-19. Programming the PSoC4 Pioneer Kit Using PSoC Programmer



KitProg/170B172E0025240(

Device Family: CY8C4xxx

Device: CY8C4245AXI-018

Programming Parameters

File Path: Pioneer_Kit_Demo.cydsn\CortexM0\ARM_GCC_473\Release\PSoC4_Pioneer_Kit_Demo.hex

Programmer: KitProg/170B172E00252400

Programming Mode: [✓ Reset] Power Cycle Power Detect

Verification: [✓ On] Off

AutoDetection: [✓ On] Off

Connector: [✓ 5p] 10p

Clock Speed: 1.6 MHz

Programmer Characteristics

Protocol: JTAG [✓ SWD] ISSP I2C

Voltage: [✓ 5.0 V] 3.3 V 2.5 V 1.8 V

Status

Execution Time: 3.9 seconds

Power Status: ON

Voltage: 3354 mV

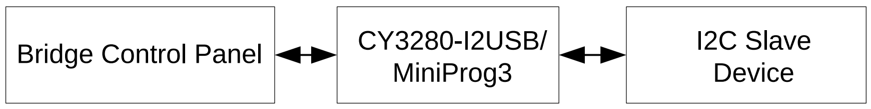
```
Actions                     Results
Program Finished at
5:55:26 PM
                            Programming Succeeded
                            Doing Checksum
                            Doing Protect
                            Verifying of Flash Succeeded...
                            Verifying of Flash Starting...
                            Programming of Flash Succeeded...
                            Programming of Flash Starting...
                            Erase Succeeded
```

For Help, press F1 PASS Powered Connected

5.2.4 Configuring CY8CMBR3xxx Using Bridge Control Panel

The Bridge Control Panel (BCP) is a software tool that can be used as I^{2}C Master to communicate with the I^{2}C slave devices using CY3240-I2USB or MiniProg3 hardware, as Figure 5-20 shows.

Figure 5-20. Bridge Control Panel Communication with I^{2}C Slave Device



Note: The CY3280-MBR3 Evaluation kit does not require an additional I2USB/MiniProg3 hardware. This kit has an onboard I2C-USB bridge to connect to BCP. To connect the onboard I2C-USB bridge to BCP change the jumper position on header J13 on MBR3 Evaluation Kit to connect pins J13-1 and J13-2 and on header J14 to connect pins J13-1 and J13-2.

This tool can be used to configure the CY8CMBR3xxx controller and read debug data using I^{2}C Interface. It is highly recommended to use EZ-Click to configure the CY8CMBR3xxx controller instead of BCP. However, there might be situations where BCP can be used to configure the CY8CMBR3xxx controller. For example, to override the threshold parameter and manually specify them, use BCP tool. For more information on using the BCP tool, click on BCP “Help” menu in the BCP tool.

This section refers to various register names in the CY8CMBR3xxx controller. Refer to the CY8CMBR3xxx Registers TRM for definitions and address of these registers.

5.2.4.1 *Procedure to Configure CY8CMBR3xxx Using Bridge Control Panel*

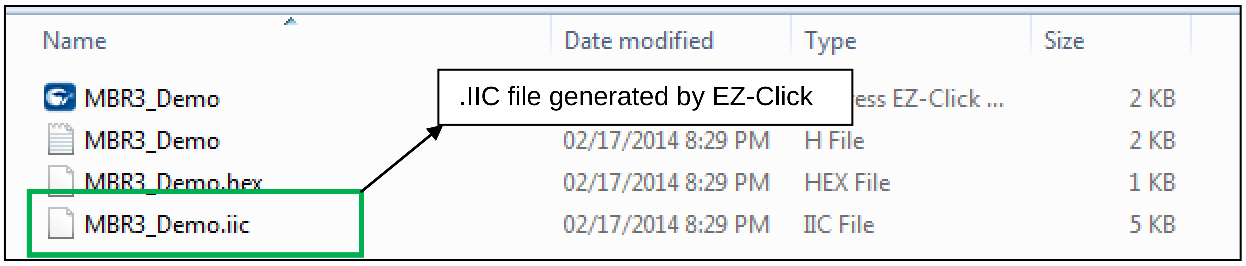
The flowchart for configuring the CY8CMBR3xxx using the BCP tool is shown in Figure 5-23.

The procedure to configure the CY8CMBR3xxx using BCP tool can be divided into four steps:

1. Send the configuration data to the CY8CMBR3xxx controller. The configuration data can be one of the following:

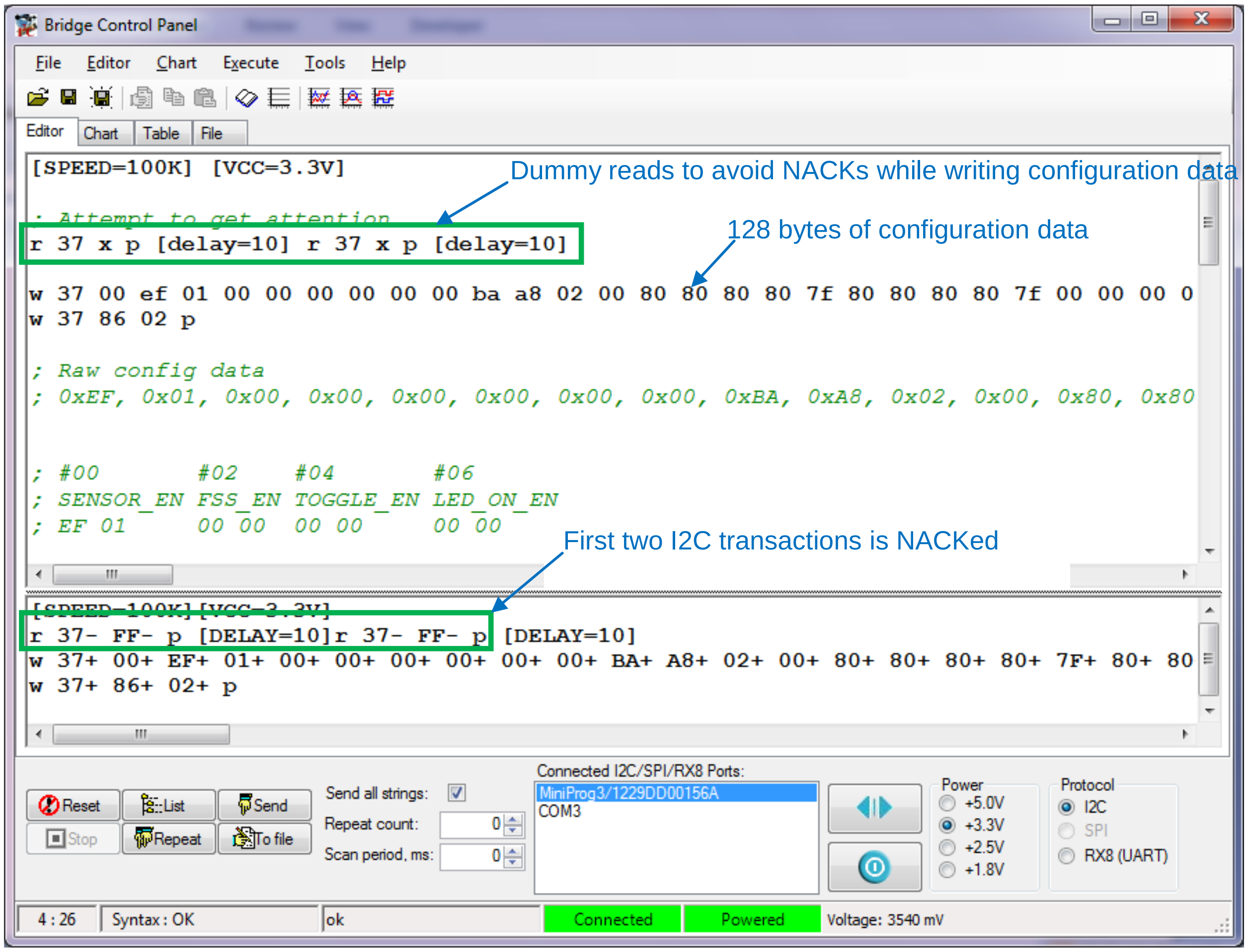
   a) The configuration file (<project_name>.iic file) generated by the EZ-Click:
   Configuring the CY8CMBR3xxx controller using the configuration file generated by EZ-Click is shown in Figure 5-21.This method is rarely used since the CY8CMBR3xxx can be directly configured using EZ-Click. Click on "Help" option in the BCP tool for instructions on opening any IIC (configuration) file in BCP tool and sending the commands to the slave device.

Figure 5-21. IIC file generated by EZ-Click to configure the CY8CMBR3xxx controller using BCP



Name	Date modified	Type	Size
MBR3_Demo		ess EZ-Click ...	2 KB
MBR3_Demo	02/17/2014 8:29 PM	H File	2 KB
MBR3_Demo.hex	02/17/2014 8:29 PM	HEX File	1 KB
MBR3_Demo.iic	02/17/2014 8:29 PM	IIC File	5 KB

Figure 5-22. Example Configuration File Generated by the EZ-Click Customizer Tool


Bridge Control Panel
File Editor Chart Execute Tools Help
Editor Chart Table File
Dummy reads to avoid NACKs while writing configuration data
128 bytes of configuration data
First two I2C transactions is NACKed
Reset
Stop
List
Repeat
Send
To file
Connected I2C/SPI/RX8 Ports:
Power
Protocol

```
[SPEED=100K] [VCC=3.3V]

; Attempt to get attention
r 37 x p [delay=10] r 37 x p [delay=10]

w 37 00 ef 01 00 00 00 00 00 00 ba a8 02 00 80 80 80 80 7f 80 80 80 80 7f 00 00 00 0
w 37 86 02 p

; Raw config data
; 0xEF, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00, 0xBA, 0xA8, 0x02, 0x00, 0x80, 0x80


; #00        #02    #04        #06
; SENSOR_EN FSS_EN TOGGLE_EN LED_ON_EN
; EF 01      00 00  00 00      00 00
```

```
[SPEED=100K][VCC=3.3V]
r 37- FF- p [DELAY=10]r 37- FF- p [DELAY=10]
w 37+ 00+ EF+ 01+ 00+ 00+ 00+ 00+ 00+ 00+ BA+ A8+ 02+ 00+ 80+ 80+ 80+ 80+ 7F+ 80+ 80
w 37+ 86+ 02+ p
```

Send all strings: ☑
Repeat count: 0
Scan period, ms: 0

MiniProg3/1229DD00156A
COM3

Power: +5.0V [✓ +3.3V] +2.5V +1.8V
Protocol: [✓ I2C] SPI RX8 (UART)

4 : 26 | Syntax : OK | ok | Connected | Powered | Voltage: 3540 mV

b) Custom commands entered in the BCP tool :

Configuring the CY8CMBR3xxx by entering custom commands in BCP is shown in Figure 5-25. In this method all the 128 configuration registers or any specific register can be configured. When the CY8CMBR3xxx is configured using custom command, it is required to compute the CRC (Cyclic Redundancy Check) of the first 126 bytes of the configuration data and write it to CONFIG_CRC (0x7E) register. This CRC value will be used by the CY8CMBR3xxx controller to verify the integrity of the configuration data.

Note: When an I^{2}C command (read/write) is sent to the CY8CMBR3xxx controller it might NACK the I^{2}C transaction. In this case insert dummy I^{2}C read transactions while writing or reading any register, as shown in Figure 5-25.

The CRC value of the first 126 bytes of configuration data can be calculated in two ways:

- Use the CY8CMBR3xxx controller to calculate the CRC value: The CY8CMBR3xxx controller calculates the checksum of the configuration data when a CMD_OP_CODE value of ‘3’ is written to the CTRL_CMD (0x86) register, as shown in Figure 5-24. The calculated CRC value will be stored in the CALC_CRC (0x94) register after 220 ms. The user has to read the CRC value from the CALC_CRC (0x94) register and manually write it to the CONFIG_CRC (0x7E) register. This method should be used only during testing and debugging the CY8CMBR3xxx controller. For configuring the CY8CMBR3xxx controller in production use the CRC API provided with the Host APIs.

- Use the Host APIs to calculate the CRC value: Cypress provides Host APIs to configure the CY8CMBR3xxx using host processor. The Host APIs has source code which can be used to compute the CRC value of the 126 bytes of the configuration data. The user should use this code to calculate the CRC and write the calculated CRC value to the CONFIG_CRC (0x7E) register, as shown in Figure 5-25. The procedure to calculate the CRC is explained in the section 5.2.4.2. It is highly recommended to use this method to calculate the CRC value.

2. Once the configuration data and the CRC value is written to the CY8CMBR3xxx controller registers, write a CMD_OP_CODE value of ‘2’ to the CTRL_CMD (0x86) register to save the configuration data to the nonvolatile memory.
3. After writing a CMD_OP_CODE value of ‘2’ to the CTRL_CMD (0x86) register, wait for 220 ms and read the CTRL_CMD_STATUS (0x88) register to check if the configuration data is successfully saved to nonvolatile memory.

   If the configuration data is successfully saved to nonvolatile memory, the value in the CTRL_CMD_STATUS (0x88) register will be ‘0’. If the valued in the CTRL_CMD_STATUS register is ‘0’, issue reset command by writing CMD_OP_CODE value of 255 to the CTRL_CMD (0x86) register.

   If the value in the CTRL_CMD_STATUS (0x88) register is ‘1’, it means the configuration data is not saved to the nonvolatile memory. In this case read the CTRL_CMD_ERR (0x89) register to know the reason for failure to save the configuration data to nonvolatile memory.

   - A value of ‘253’ in the CTRL_CMD_ERR indicates write to nonvolatile memory failed. In this case re-write the configuration data and repeat from step 2.
   - A value of ‘254’ in the CTRL_CMD_ERR register indicates CRC value written to CONFIG_CRC (0x7E) is incorrect. In this case re-calculate the CRC for the entire 126 bytes of configuration data, write to the CONFIG_CRC (0x7E) register and repeat from step 2.
   - A value of ‘255’ in the CTRL_CMD_ERR register indicates the CMD_OP_CODE value written to the CTRL_CMD (0x86) register is not valid. In this case send a valid CMD_OP_CODE = ‘2’ and repeat step 3.

Figure 5-23. Flowchart for Configuring the CY8CMBR3xxx Using BCP

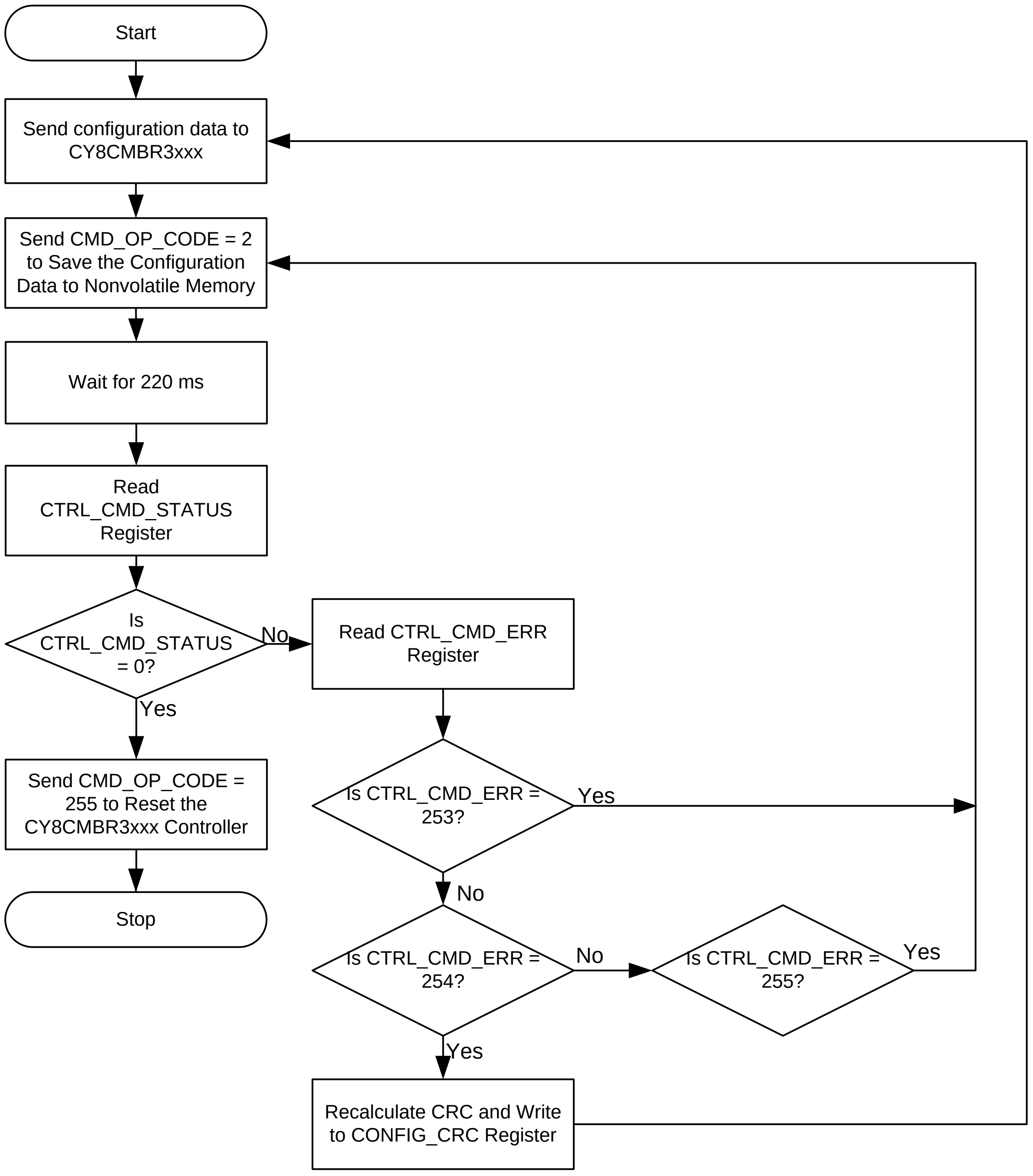
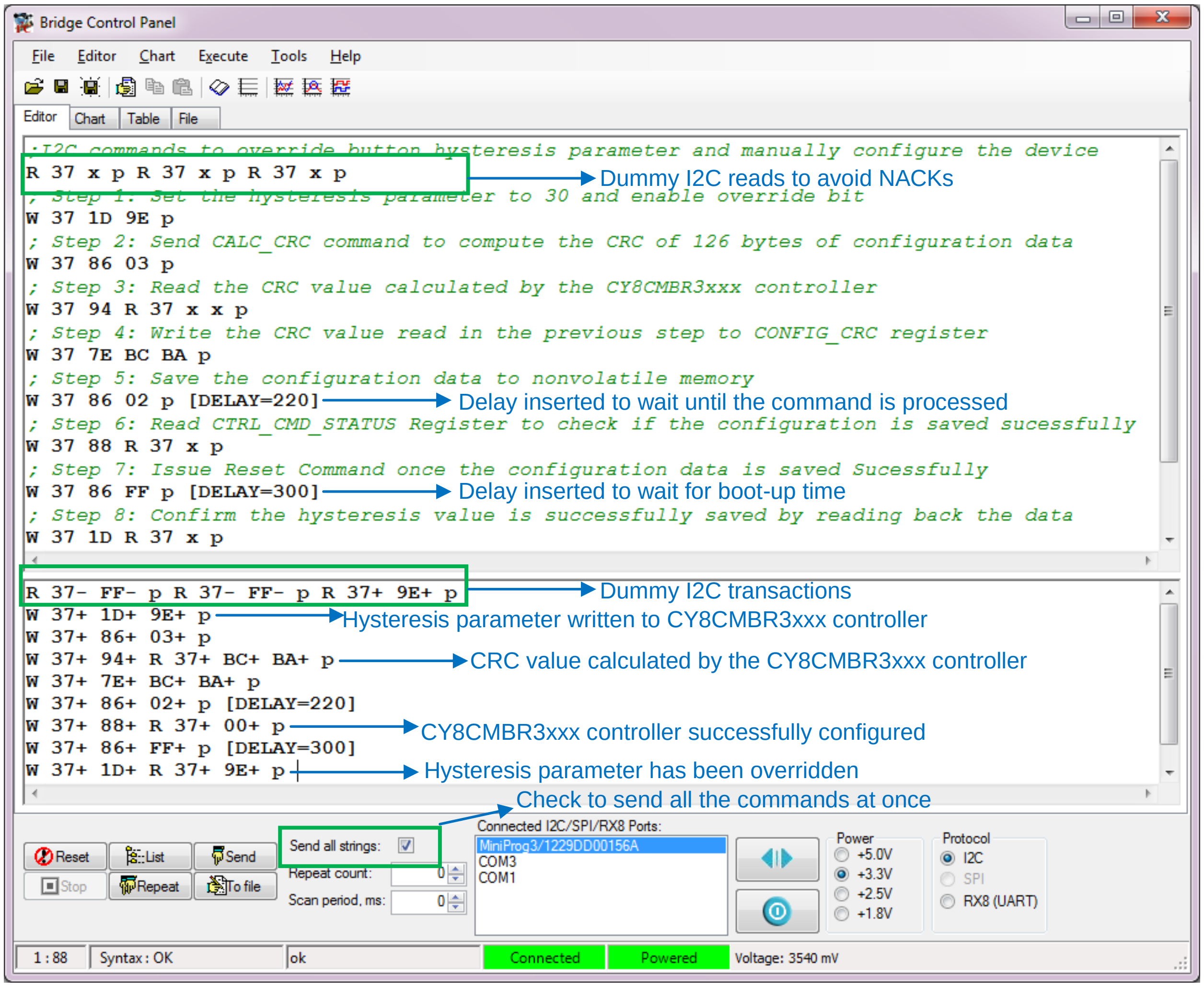

Start
Send configuration data to CY8CMBR3xxx
Send CMD_OP_CODE = 2 to Save the Configuration Data to Nonvolatile Memory
Wait for 220 ms
Read CTRL_CMD_STATUS Register
Is CTRL_CMD_STATUS = 0?
No
Yes
Read CTRL_CMD_ERR Register
Send CMD_OP_CODE = 255 to Reset the CY8CMBR3xxx Controller
Is CTRL_CMD_ERR = 253?
Yes
No
Stop
Is CTRL_CMD_ERR = 254?
No
Is CTRL_CMD_ERR = 255?
Yes
Yes
Recalculate CRC and Write to CONFIG_CRC Register

Figure 5-24. Calculating the CRC Using CY8CMBR3xxx Controller


Bridge Control Panel
File Editor Chart Execute Tools Help
Editor Chart Table File
Dummy I2C reads to avoid NACKs
Delay inserted to wait until the command is processed
Delay inserted to wait for boot-up time
Dummy I2C transactions
Hysteresis parameter written to CY8CMBR3xxx controller
CRC value calculated by the CY8CMBR3xxx controller
CY8CMBR3xxx controller successfully configured
Hysteresis parameter has been overridden
Check to send all the commands at once
Reset
Stop
List
Repeat
Send
To file

```
;I2C commands to override button hysteresis parameter and manually configure the device
R 37 x p R 37 x p R 37 x p
; Step 1: Set the hysteresis parameter to 30 and enable override bit
W 37 1D 9E p
; Step 2: Send CALC_CRC command to compute the CRC of 126 bytes of configuration data
W 37 86 03 p
; Step 3: Read the CRC value calculated by the CY8CMBR3xxx controller
W 37 94 R 37 x x p
; Step 4: Write the CRC value read in the previous step to CONFIG_CRC register
W 37 7E BC BA p
; Step 5: Save the configuration data to nonvolatile memory
W 37 86 02 p [DELAY=220]
; Step 6: Read CTRL_CMD_STATUS Register to check if the configuration is saved sucessfully
W 37 88 R 37 x p
; Step 7: Issue Reset Command once the configuration data is saved Sucessfully
W 37 86 FF p [DELAY=300]
; Step 8: Confirm the hysteresis value is successfully saved by reading back the data
W 37 1D R 37 x p
```

```
R 37- FF- p R 37- FF- p R 37+ 9E+ p
W 37+ 1D+ 9E+ p
W 37+ 86+ 03+ p
W 37+ 94+ R 37+ BC+ BA+ p
W 37+ 7E+ BC+ BA+ p
W 37+ 86+ 02+ p [DELAY=220]
W 37+ 88+ R 37+ 00+ p
W 37+ 86+ FF+ p [DELAY=300]
W 37+ 1D+ R 37+ 9E+ p
```

Send all strings: [✓]
Repeat count: 0
Scan period, ms: 0

Connected I2C/SPI/RX8 Ports:
MiniProg3/1229DD00156A
COM3
COM1

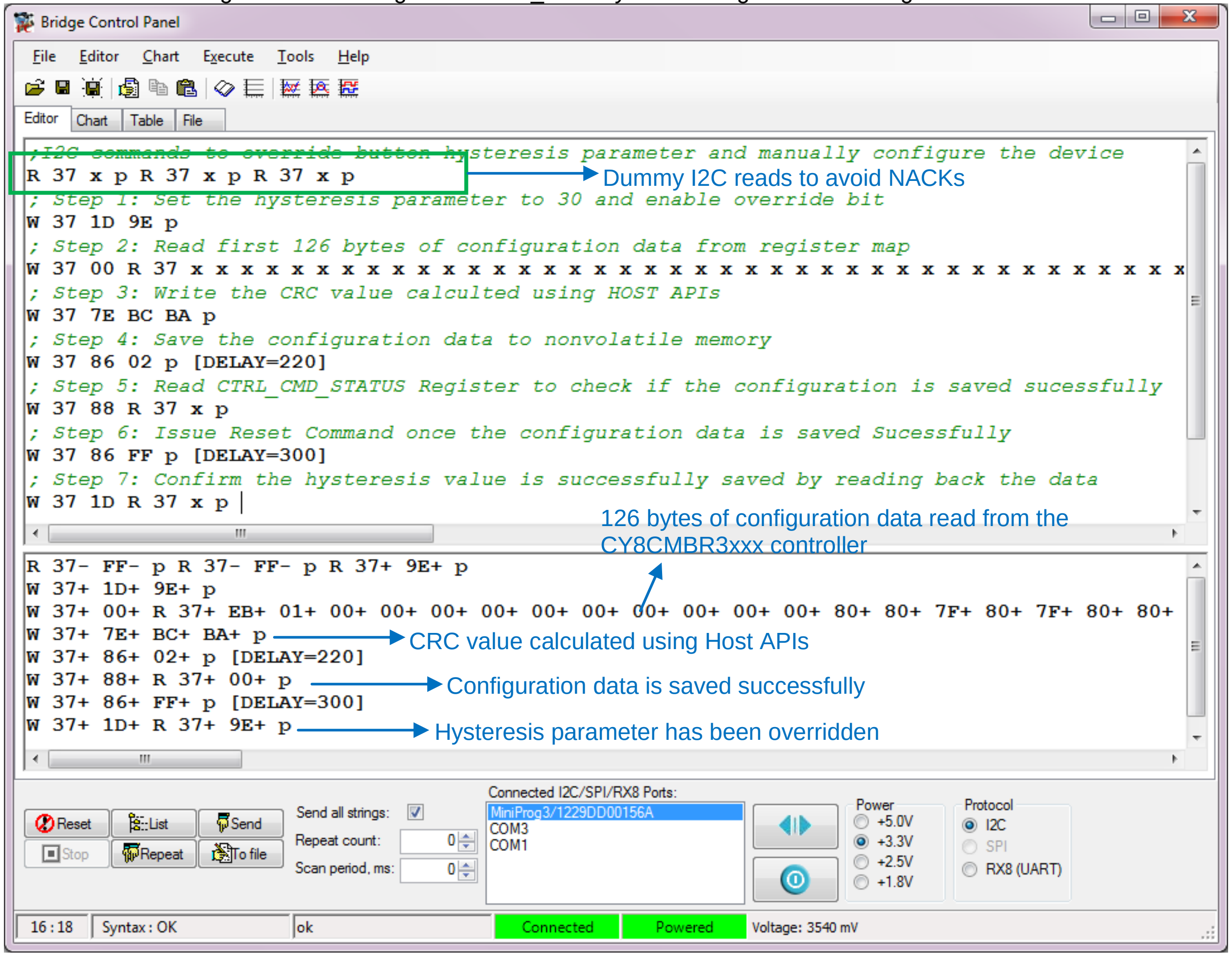
Power: +5.0V [● +3.3V] +2.5V +1.8V

Protocol: [● I2C] SPI RX8 (UART)

1 : 88 | Syntax : OK | ok | Connected | Powered | Voltage: 3540 mV

Note: All the commands entered in the BCP can be sent at once by checking the “send all strings” box and clicking send button.

Figure 5-25. Writing to CONFIG_CRC by Calculating the CRC Using Host APIs


Bridge Control Panel
File
Editor
Chart
Execute
Tools
Help
Editor
Chart
Table
File
Dummy I2C reads to avoid NACKs
126 bytes of configuration data read from the CY8CMBR3xxx controller
CRC value calculated using Host APIs
Configuration data is saved successfully
Hysteresis parameter has been overridden
Reset
List
Send
Stop
Repeat
To file

```
;I2C commands to override button hysteresis parameter and manually configure the device
R 37 x p R 37 x p R 37 x p
; Step 1: Set the hysteresis parameter to 30 and enable override bit
W 37 1D 9E p
; Step 2: Read first 126 bytes of configuration data from register map
W 37 00 R 37 x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x
; Step 3: Write the CRC value calculted using HOST APIs
W 37 7E BC BA p
; Step 4: Save the configuration data to nonvolatile memory
W 37 86 02 p [DELAY=220]
; Step 5: Read CTRL_CMD_STATUS Register to check if the configuration is saved sucessfully
W 37 88 R 37 x p
; Step 6: Issue Reset Command once the configuration data is saved Sucessfully
W 37 86 FF p [DELAY=300]
; Step 7: Confirm the hysteresis value is successfully saved by reading back the data
W 37 1D R 37 x p
```

```
R 37- FF- p R 37- FF- p R 37+ 9E+ p
W 37+ 1D+ 9E+ p
W 37+ 00+ R 37+ EB+ 01+ 00+ 00+ 00+ 00+ 00+ 00+ 00+ 00+ 00+ 00+ 80+ 80+ 7F+ 80+ 7F+ 80+ 80+
W 37+ 7E+ BC+ BA+ p
W 37+ 86+ 02+ p [DELAY=220]
W 37+ 88+ R 37+ 00+ p
W 37+ 86+ FF+ p [DELAY=300]
W 37+ 1D+ R 37+ 9E+ p
```

Send all strings: ✓
Repeat count: 0
Scan period, ms: 0

Connected I2C/SPI/RX8 Ports:
MiniProg3/1229DD00156A
COM3
COM1

Power: ○ +5.0V [✓ +3.3V] ○ +2.5V ○ +1.8V

Protocol: [✓ I2C] ○ SPI ○ RX8 (UART)

16 : 18 | Syntax : OK | ok | Connected | Powered | Voltage: 3540 mV

5.2.4.2 *Procedure to Calculate the CRC16-CCITT Using Host APIs*

The CY8CMBR3xxx controller requires the user to specify the CRC value for the 126 bytes of configuration data. The CRC algorithm implemented in the CY8CMBR3xxx controller is CRC16-CCITT.

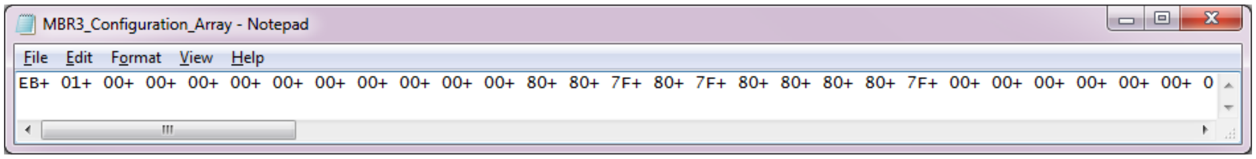
Follow the below procedure to calculate the CRC using the Host APIs:

1. Download a C IDE. In the example shown in Figure 5-28, eclipse IDE for C/C++ is used.
2. Create a C project and include the CY8CMBR3xxx_APIs.h and CY8CMBR3xxx_CRC.c files in your project. These files are part of the Host APIs.
3. Create a new source file with suitable title. In the example shown in Figure 5-28 the source file name is "main.c".
4. In the main.c file, enter the following code shown in the Figure 5-28.

```
#include <stdio.h>

/* Variable to store 126 bytes of configuration data */
unsigned char CY8CMBR3xxx_configuration[126]= { };

/* The main() function invokes the CY8CMBR3xxx_CalculateCrc API to compute the CRC for 126 bytes of
 * configuration data */
int main(void)
{
        /* Variable to store the 16-bit CRC value*/
        unsigned short crcValue;

        /* Call the "CY8CMBR3xxx_CalculateCrc" API with configuration data address as the argument*/
        crcValue = CY8CMBR3xxx_CalculateCrc(CY8CMBR3xxx_configuration);

        /* Print the calculated 16-bit CRC value*/
        printf("The CRC for the given configuration data is: 0x%x",crcValue);

        return 0;
}
```

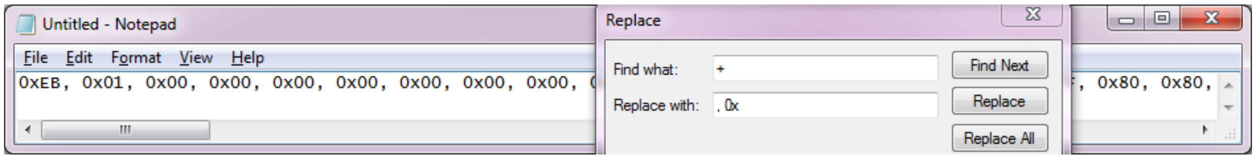
5. Read the 126 bytes of configuration data from the CY8CMBR3xxx controller using BCP and copy this into a text editor software (such as Notepad) to format the data i.e. to remove all the "+" symbols from the copied array and replace it with ",0x" character in front of each byte data as shown in Figure 5-26 and Figure 5-27.

Figure 5-26. CY8CMBR3xxx Configuration Data Copied from BCP to Notepad


MBR3_Configuration_Array - Notepad
File Edit Format View Help

```
EB+ 01+ 00+ 00+ 00+ 00+ 00+ 00+ 00+ 00+ 00+ 00+ 80+ 80+ 7F+ 80+ 7F+ 80+ 80+ 80+ 80+ 7F+ 00+ 00+ 00+ 00+ 00+ 00+ 0
```

Figure 5-27. CY8CMBR3xxx Configuration Data Formatted in Notepad



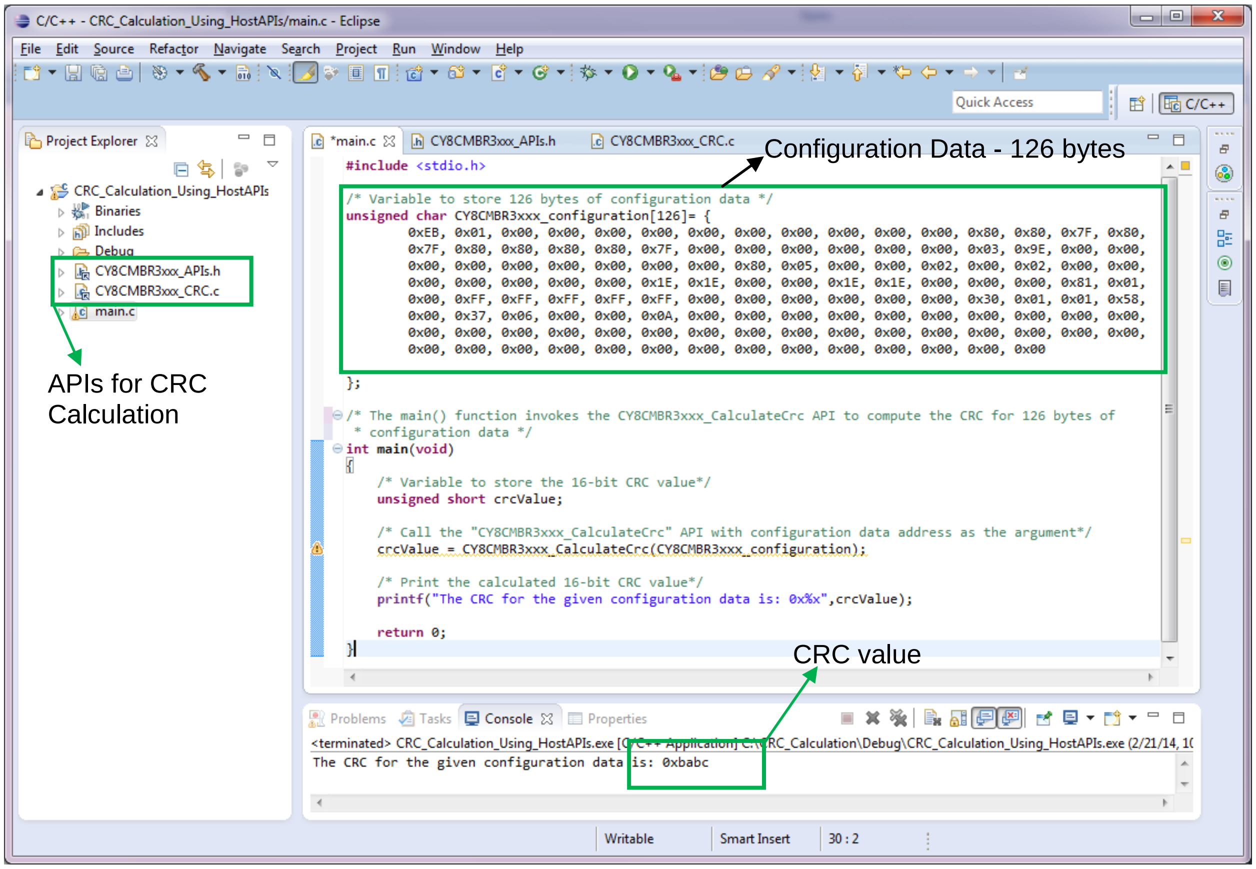
```
0xEB, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, (
```

Find what: +
Replace with: , 0x

```
, 0x80, 0x80,
```

6. Copy this formatted array into the "CY8CMBR3xxx_configuration [126]" array in the main.c, as shown in Figure 5-27.
7. Save and build the project. Ensure there are no errors.
8. Once the project is successfully built, click on "Run" button to get the CRC value.

Figure 5-28. Computing CRC Value Using Host APIs in Eclipse C/C++ IDE



```c
#include <stdio.h>

/* Variable to store 126 bytes of configuration data */
unsigned char CY8CMBR3xxx_configuration[126]= {
        0xEB, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x80, 0x80, 0x7F, 0x80,
        0x7F, 0x80, 0x80, 0x80, 0x80, 0x7F, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x03, 0x9E, 0x00, 0x00,
        0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x80, 0x05, 0x00, 0x00, 0x02, 0x00, 0x02, 0x00, 0x00,
        0x00, 0x00, 0x00, 0x00, 0x00, 0x1E, 0x1E, 0x00, 0x00, 0x1E, 0x1E, 0x00, 0x00, 0x00, 0x81, 0x01,
        0x00, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x30, 0x01, 0x01, 0x58,
        0x00, 0x37, 0x06, 0x00, 0x00, 0x0A, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
        0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
        0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00

};

/* The main() function invokes the CY8CMBR3xxx_CalculateCrc API to compute the CRC for 126 bytes of
 * configuration data */
int main(void)
{
    /* Variable to store the 16-bit CRC value*/
    unsigned short crcValue;

    /* Call the "CY8CMBR3xxx_CalculateCrc" API with configuration data address as the argument*/
    crcValue = CY8CMBR3xxx_CalculateCrc(CY8CMBR3xxx_configuration);

    /* Print the calculated 16-bit CRC value*/
    printf("The CRC for the given configuration data is: 0x%x",crcValue);

    return 0;
}
```

```
<terminated> CRC_Calculation_Using_HostAPIs.exe [C/C++ Application] C:\CRC_Calculation\Debug\CRC_Calculation_Using_HostAPIs.exe (2/21/14, 1(
The CRC for the given configuration data is: 0xbabc
```

6. CapSense Performance Tuning

As explained in the CapSense Technology chapter, Cypress's SmartSense Auto-tuning algorithm eliminates the need for manual tuning by automatically tuning the hardware and firmware parameters. However, the SmartSense algorithm requires setting the sensitivity parameter value of the sensor to ensure the SNR of all the sensors is greater than 5:1. The CY8CMBR3xxx allows to manually setting the threshold parameters. This section explains how to set the sensitivity of the sensor and threshold parameters for reliable touch detection.

6.1 General Considerations

6.1.1 Signal, Noise, and SNR

A well-tuned CapSense system reliably discriminates between ON and OFF sensor states. To achieve a robust level of performance, the CapSense signal must be significantly larger than the CapSense noise. The CapSense signal is compared to the CapSense noise by using a quantity called signal-to-noise ratio (SNR). For more in-depth information on SNR refer to the "CapSense Technology" chapter in *Getting Started with CapSense*. According to CapSense best practices, it is required to have a minimum SNR of 5:1 for all sensors. The SNR of sensor is given by the equation:

$$\text{SNR} = \frac{Signal}{Peak-to-Peak\ Noise} \qquad \text{Equation 4}$$

Where: Signal = Raw count – Baseline

Peak-to-Peak Noise = Peak-to-Peak noise of raw count measured over 3000 samples

Therefore, the key to achieve a high SNR is to increase the signal and decrease the noise.

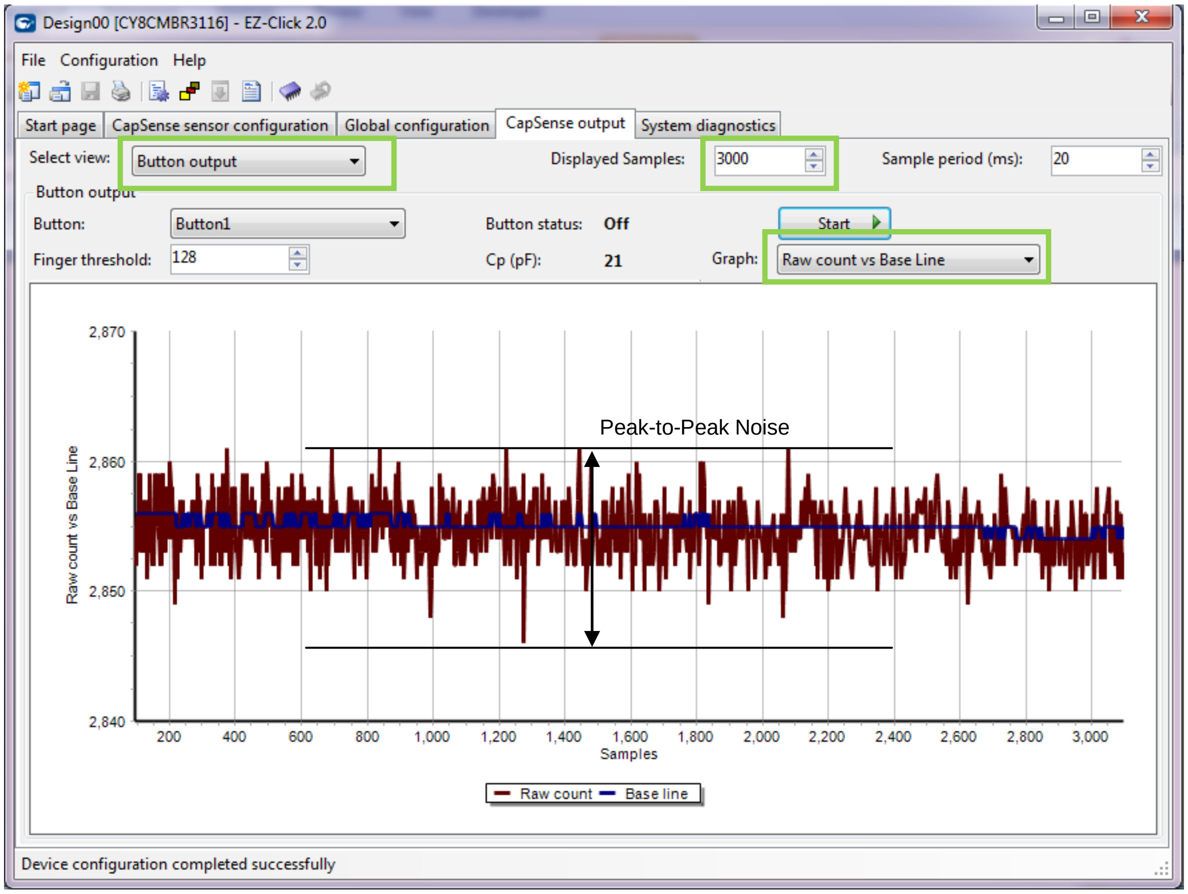
6.1.1.1 *Noise Counts Measurement*

To compute the SNR, it is required to measure the signal and noise counts of the sensor.

To measure the noise counts using EZ-Click, follow these steps:

1. Generate the configuration file and download the configuration to the device.
2. Go to the "CapSense output" tab and select the "Raw count vs Baseline" graph. Set the "Displayed Samples" field to 3000.
3. Click on the "Start" button and wait until 3000 samples are acquired.
   Note: The sensor should not be touched while acquiring raw count samples to measure noise counts.
4. Measure the noise count which is equal to the raw count (max) – raw count (min), as Figure 6-1 shows. The noise counts for the graph shown in Figure 6-1 is 2860 – 2845 = 15 counts.

Figure 6-1. Measuring Noise in EZ-Click Customizer



Design00 [CY8CMBR3116] - EZ-Click 2.0

Select view: Button output

Displayed Samples: 3000

Sample period (ms): 20

Button output

Button: Button1

Button status: Off

Finger threshold: 128

Cp (pF): 21

Graph: Raw count vs Base Line

Device configuration completed successfully

6.1.1.2 *Signal Measurement*

After the noise count is measured, it is required to measure the signal of the sensor to compute the SNR.

To measure the signal, follow these steps:

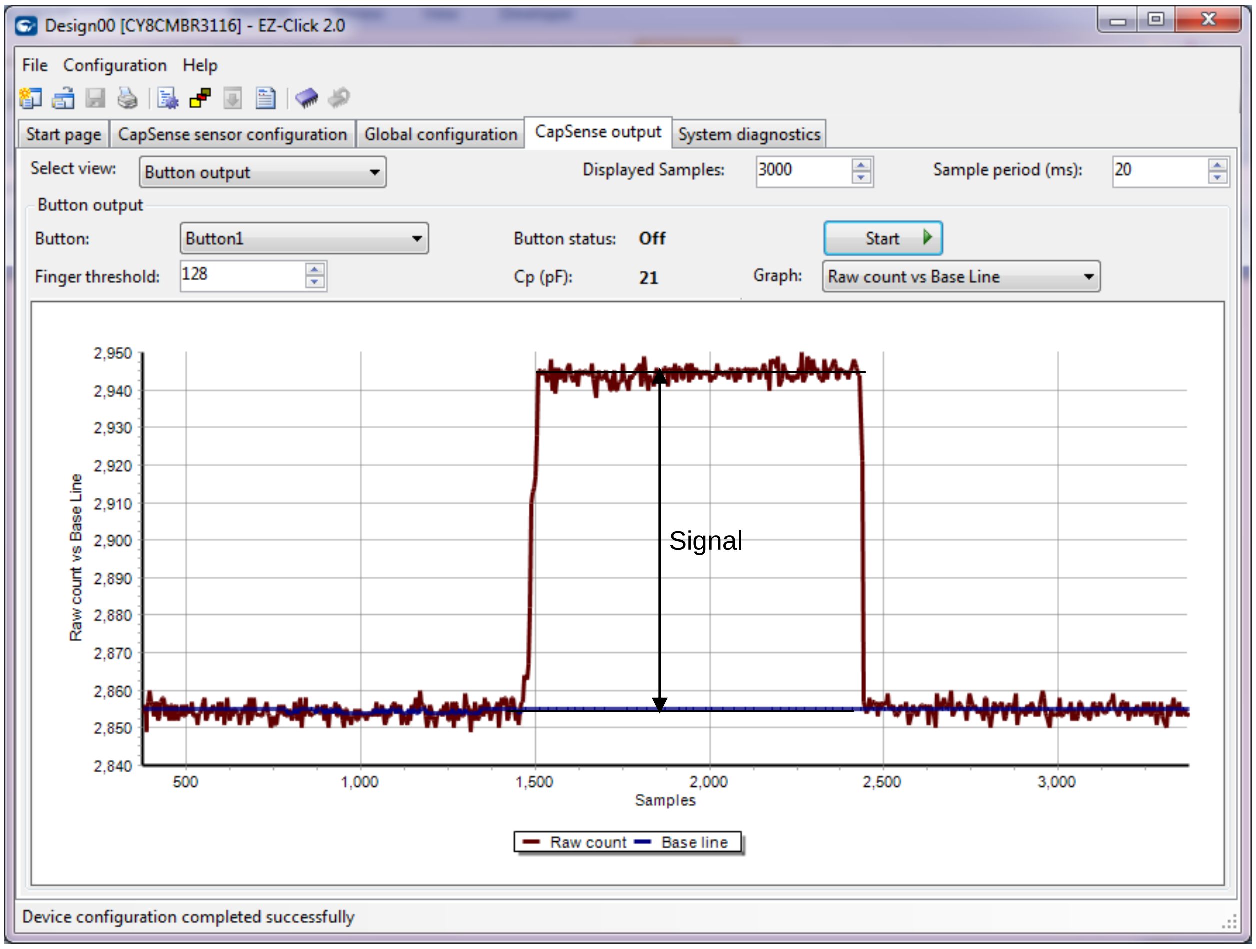
1. In the CapSense output tab, click on the “Start” button to view the “Raw count vs Baseline” graph.
2. Touch the sensor for 1000 samples and then release the finger.
3. Measure the shift in raw counts from the *no touch* to touch state, as Figure 6-2 shows.

Signal = Average value of the raw count (When sensor is touched) - Average value of raw count (When sensor is not touched)

For the graph shown in Figure 6-2, Signal = 2945 - 2855 = 90 counts

SNR $= \frac{90}{15} = 6:1$

Figure 6-2. Measuring the Signal in EZ-Click Customizer



Select view: Button output

Displayed Samples: 3000

Sample period (ms): 20

Button output

Button: Button1

Button status: Off

Finger threshold: 128

Cp (pF): 21

Graph: Raw count vs Base Line

Device configuration completed successfully

6.2 Tuning the Buttons, Sliders, and Guard Sensor

Figure 6-3 shows the typical flow of tuning the buttons, sliders and guard sensors.

Tuning a sensor in the CY8CMBR3xxx controller is divided into two sections:

1. Ensure SNR is greater than 5:1
2. Set threshold parameters to the recommended value

6.2.1 Method to Ensure Minimum SNR

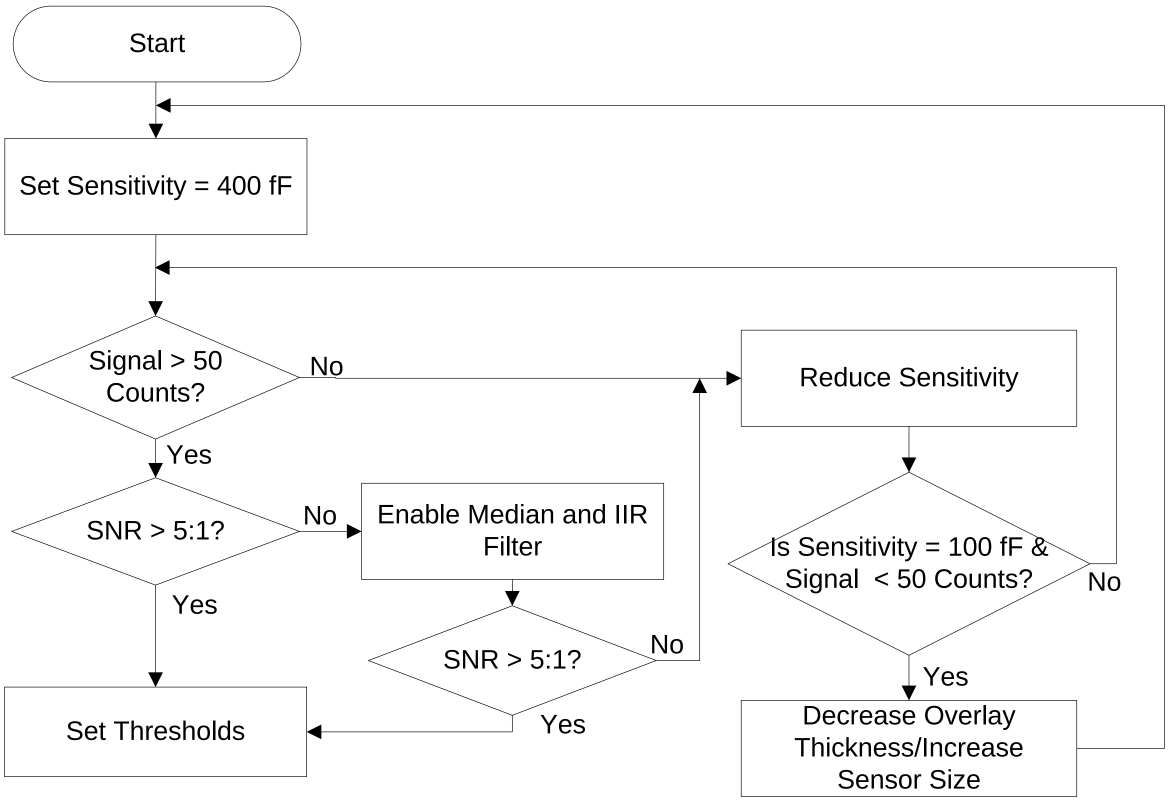
To ensure that the SNR is greater than 5:1, follow these steps:

1. Set the sensitivity of the sensor to 400 fF and measure the signal.
2. If the signal is less than 50 counts, lower the sensitivity value until the signal is greater than 50 counts. If the signal is not greater than 50 counts even after setting the lowest sensitivity value (that is, 100 fF), reduce the overlay thickness or increase the sensor size.
3. When the signal is greater than 50 counts, measure the noise counts. If the noise is greater than one-fifth of the signal, enable filters to reduce the noise. Enable the IIR filter and measure the noise counts. If the noise is still greater than one-fifth of the signal, enable the Median filter. If the median filter is enabled, the Automatic Threshold feature should be disabled and the Finger Threshold parameter should be manually specified.
4. Calculate the SNR, and if SNR is greater than 5:1, proceed to set the threshold parameters.

5. If the SNR is not greater than 5:1 even after enabling filters, lower the sensitivity value and calculate the SNR. If the SNR is less than 5:1 after setting the lowest value of sensitivity (that is, 100 fF) and enabling filters, reduce the overlay thickness or increase the sensor size to achieve an SNR greater than 5:1.

Note: For sliders, the signal should always be less than 255 to get accurate centroid position. If the signal is greater than 255, increase the sensitivity parameter until the signal is less than 255.

Figure 6-3. Buttons, Sliders, and Guard Sensor Tuning


Start
Set Sensitivity = 400 fF
Signal > 50 Counts?
No
Yes
Reduce Sensitivity
SNR > 5:1?
No
Enable Median and IIR Filter
Is Sensitivity = 100 fF & Signal < 50 Counts?
No
Yes
SNR > 5:1?
No
Yes
Set Thresholds
Yes
Decrease Overlay Thickness/Increase Sensor Size

6.2.2 Button Threshold Parameters

After ensuring that all the sensors meet SNR greater than 5:1, the threshold parameters can be specified.

The following threshold parameters are applicable for buttons and guard sensor:

- Finger threshold
- Hysteresis
- Noise threshold
- Negative Noise threshold
- Low-Baseline Reset

Section 6.2.3 explains when and how to set these parameters.

6.2.2.1 *Finger Threshold*

The finger threshold parameter is used to judge the active/inactive state of a sensor. If the difference count value of a sensor is greater than the finger threshold + hysteresis, the sensor is judged as ON and if the difference count of the sensor is less than the finger threshold value – hysteresis, the sensor is judged as OFF. The finger threshold can range from 31 to 200; the default value is set to 128. See Table 6-2 to set this parameter.

The relationship between finger threshold and sensor ON/OFF state is given by:

$$\text{Sensor State} = \begin{cases} \text{ON} & \text{if } (\text{Signal } \geq \text{Finger Threshold} + \text{Hysteresis}) \\ \text{OFF} & \text{if } (\text{Signal } \leq \text{Finger Threshold} - \text{Hysteresis}) \end{cases} \qquad \text{Equation 5}$$

6.2.2.2 *Hysteresis*

The hysteresis parameter is used along with the finger threshold parameter to determine the ON/OFF state of the sensor. Hysteresis provides immunity against noisy transitions of the sensor state. This parameter is applicable only for buttons and guard sensor. This parameter can range from 0 to 31; the default value is set to 12. See Table 6-2 to set this parameter.

6.2.2.3 *Noise Threshold*

The noise threshold parameter sets the raw count limit above which the baseline is not updated, as Figure 6-4 shows. In other words, the baseline remains constant as long as the raw count is above (baseline + noise threshold). This keeps the baseline from becoming too high due to a finger touch. This parameter can range from 0 to 127; the default value is set to 51. See Table 6-2 to set this parameter.

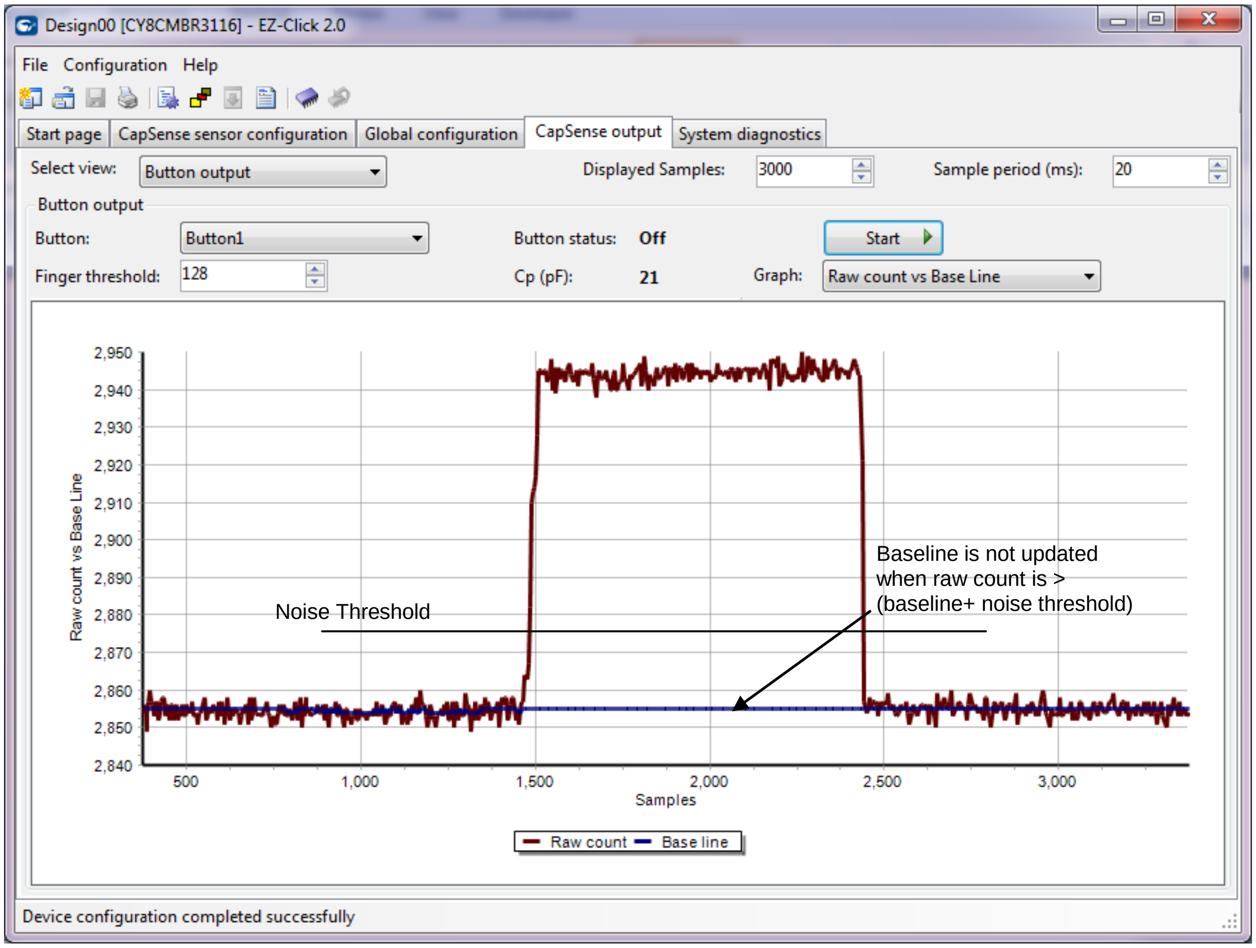
6.2.2.4 *Negative Noise Threshold*

If the raw count is less than (baseline – negative noise threshold) for the number of samples specified by the low-baseline reset parameter, the baseline is reset to the new raw count value. This change in baseline resets any sensor that is stuck in the active state during the device power ON i.e. sensor touched during controller power-up. This parameter can range from 0 to 127; default value is set to 51. See Table 6-2 to set this parameter.

6.2.2.5 *Low-Baseline Reset*

This parameter is used along with the negative noise threshold parameter to reset the baseline when the baseline is higher than the raw count. It counts the number of abnormally low raw counts required to reset the baseline. It is used to reset the baseline if the finger is placed on the sensor during device startup and later removed. This parameter can range from 0 to 127; the default value is set to 50. See Table 6-2 to set this parameter.

Figure 6-4. Noise Threshold


Design00 [CY8CMBR3116] - EZ-Click 2.0

Select view: Button output
Displayed Samples: 3000
Sample period (ms): 20
Button output
Button: Button1
Button status: Off
Finger threshold: 128
Cp (pF): 21
Graph: Raw count vs Base Line

Device configuration completed successfully

6.2.3 Setting the Thresholds for the Button, Slider, and Guard Sensors

Table 6-1 shows the threshold parameters that are applicable for button, slider, and guard sensor.

CY8CMBR3xxx provides the Automatic Threshold feature for buttons. This feature should always be enabled unless the user requires specifying the finger threshold manually.

Slider sensors require the user to specify the finger threshold parameter manually because the automatic threshold feature is not applicable to slider sensor. The SmartSense auto-tuning algorithm automatically sets all other threshold parameters.

To manually specify the threshold parameters such as noise threshold, negative noise threshold, and low-baseline reset, set the respective threshold override bit in the respective threshold register and specify these thresholds manually. It is recommended not to override the threshold parameters. To set the threshold override bit and specify the threshold parameters such as noise threshold, negative noise threshold, and low-baseline reset parameter, use Bridge Control Panel (BCP) tool. EZ-click does not provide option to override or specify threshold parameters.

Table 6-1. Threshold Parameters for Button, Slider, and Guard Sensors

Threshold Parameter	**Sensor Type**		
	Button	**Slider**	**Guard**
Finger Threshold	Set only if the Automatic Threshold feature is disabled	Should always be set manually	Set only if the Automatic Threshold feature is disabled
Noise Threshold	Set only if the Noise Threshold Override bit is enabled	Set only if the Slider Noise Threshold Override bit is enabled	Set only if the Noise Threshold Override bit is enabled
Negative Noise Threshold	Set only if the Negative Noise Threshold Override bit is enabled	Set only if the Slider Negative Noise Threshold Override bit is enabled	Set only if the Negative Noise Threshold Override bit is enabled
Hysteresis	Set only if the Hysteresis Threshold Override bit is enabled	Not Applicable	Set only if the Hysteresis Threshold Override bit is enabled
Low-Baseline Reset	Set only if the Low-Baseline Reset Override bit is enabled	Set only if the Slider Low-Baseline Reset Override bit is enabled	Set only if the Low-Baseline Reset Override bit is enabled

Note: CY8CMBR3xxx has separate registers for the button and slider sensors to set the noise threshold, negative noise threshold, and low-baseline reset parameters.

Follow the below procedure to set these threshold parameters:

1. In the CapSense output tab, select the “Diff count vs. Finger threshold” graph and click on the Start button.
2. Touch the sensor and measure the difference count, as Figure 6-5 shows.
   Notes:
   - The difference count in CY8CMBR3xxx controller is normalized. It will not be equal to Raw counts (touched) - Baseline.
   - If the difference count is greater than 255, it will be truncated to 255. In this case, threshold parameters cannot be set properly. Increase the sensitivity parameter value until the difference counts is less than 255. Ensure the SNR is greater than 5:1 after changing the sensitivity parameter value by following the procedure explained in section 6.2.1
3. Set the threshold parameters to values as Table 6-2 shows:

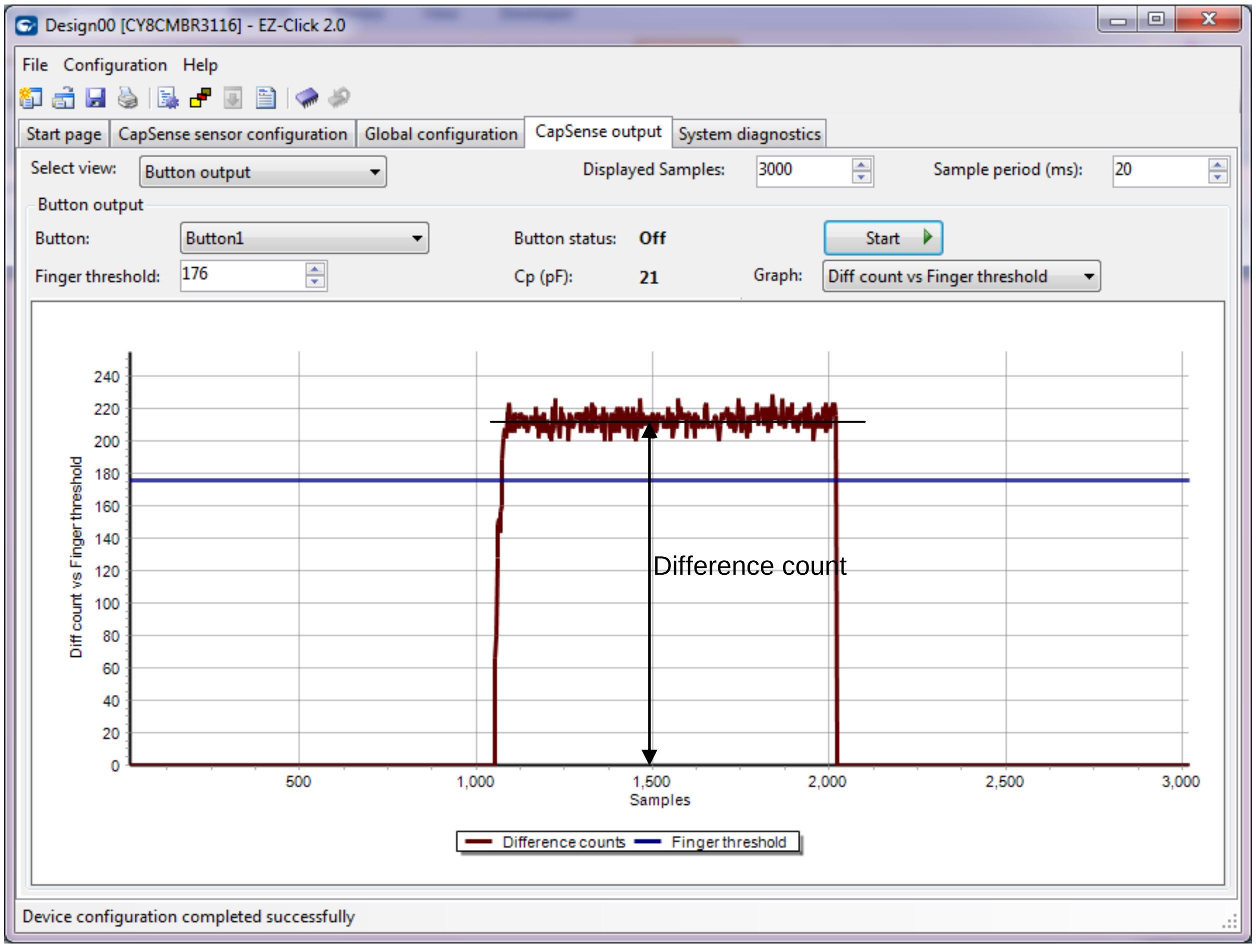
Table 6-2. Threshold Parameter Values

Threshold Parameter	Recommendation
Finger Threshold	80% of the Difference count
Noise Threshold	40% of the Difference count
Negative Noise Threshold	40% of the Difference count
Hysteresis	10% of the Difference count
Low-Baseline Reset	Set to 50

For the example shown in Figure 6-5, the difference count is approximately 210 counts and the threshold parameters are set as shown below.

Finger threshold = 80% × 210 = 168
Noise threshold = 40% × 210 = 84
Negative Noise threshold = Noise threshold = 84
Hysteresis = 10% × 210 = 21
Low Baseline reset = 50

Figure 6-5. Difference Count Measurement



Design00 [CY8CMBR3116] - EZ-Click 2.0

Select view: Button output
Displayed Samples: 3000
Sample period (ms): 20
Button output
Button: Button1
Button status: Off
Finger threshold: 176
Cp (pF): 21
Graph: Diff count vs Finger threshold

Device configuration completed successfully

6.3 Tuning a Proximity Sensor

Figure 6-6 shows the typical flow of tuning a proximity sensor.

Tuning a proximity sensor in the CY8CMBR3xxx controller has two stages:

1. Ensure SNR is greater than 5:1
2. Set appropriate threshold parameters

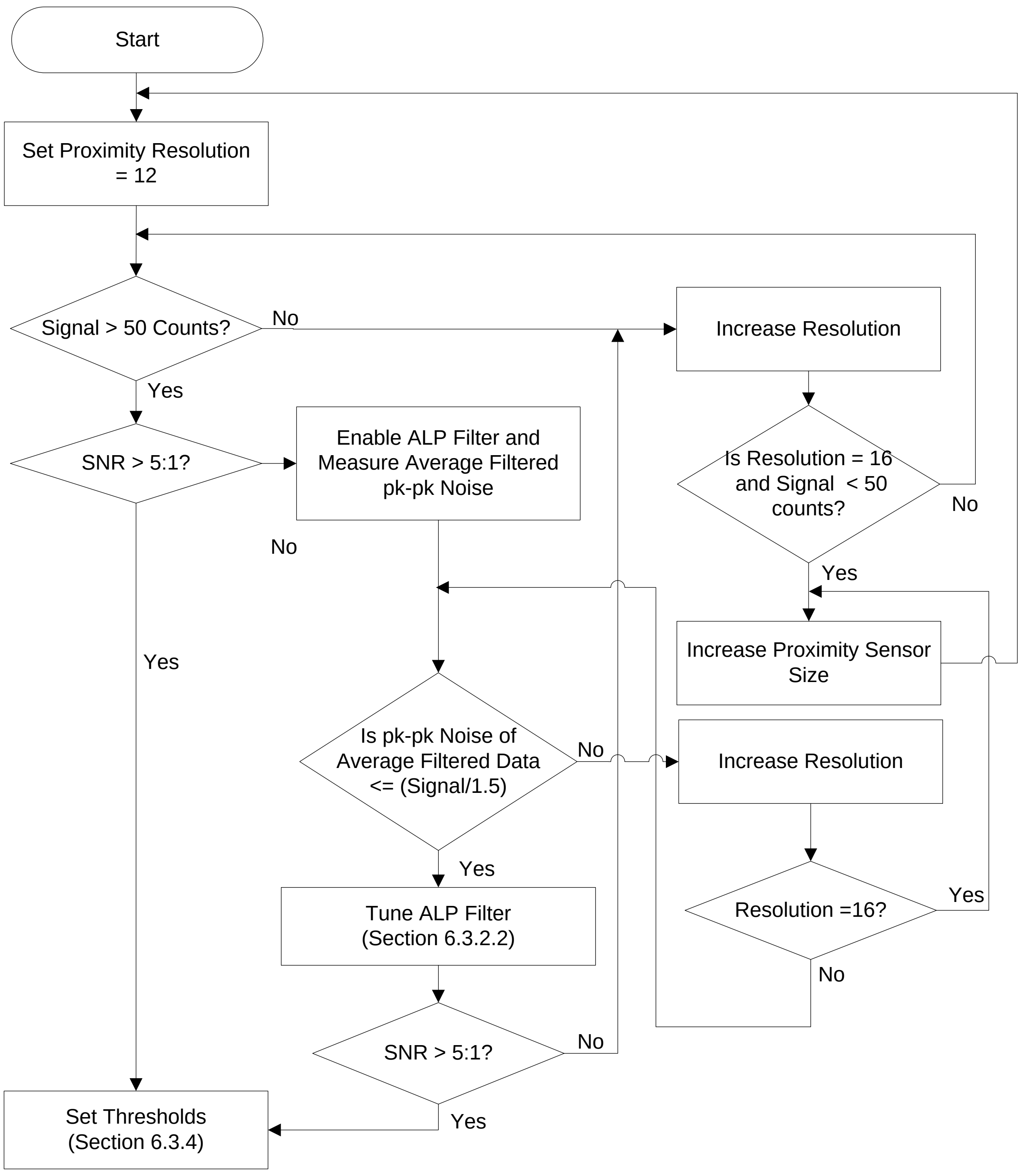
6.3.1 Method to Ensure Minimum SNR

To ensure that the SNR is greater than 5:1, follow these steps:

1. Set the resolution of the proximity sensor to 12-bit and measure the signal at the required proximity distance.
2. If the signal is less than 50 counts, increase the proximity resolution until the signal is greater than 50 counts. If the signal is not greater than 50 counts even after setting the highest resolution (that is, 16-bit), increase the proximity sensor size.
3. After the signal is greater than 50 counts, measure the noise counts, as shown in Figure 6-7. If the noise is greater than one-fifth of the signal, enable the ALP filter to reduce the noise.

   Note: For proximity sensors Median and IIR filters are not applicable.
4. Compute the SNR, and if the SNR is greater than 5:1, proceed to set the threshold parameters.
5. If SNR is not greater than 5:1 even after enabling the ALP filter, increase the resolution and compute the SNR. If the SNR is less than 5:1 even after setting the highest resolution (16-bit) and enabling the ALP filter, increase the proximity sensor size to achieve an SNR greater than 5:1.

Figure 6-6. Proximity Sensor Tuning


Start
Set Proximity Resolution = 12
Signal > 50 Counts?
No
Yes
Increase Resolution
SNR > 5:1?
Enable ALP Filter and Measure Average Filtered pk-pk Noise
Is Resolution = 16 and Signal < 50 counts?
No
No
Yes
Yes
Increase Proximity Sensor Size
Is pk-pk Noise of Average Filtered Data <= (Signal/1.5)
No
Increase Resolution
Yes
Tune ALP Filter (Section 6.3.2.2)
Resolution =16?
Yes
No
SNR > 5:1?
No
Set Thresholds (Section 6.3.4)
Yes

6.3.2 Advanced Low-Pass (ALP) Filter

The ALP filter is a combination of multiple low-pass filters specifically designed to attenuate the noise in proximity sensors. The ALP filter switches among multiple low-pass filters to achieve the maximum noise attenuation and provide optimum response time. Set the ALP parameters shown in Table 6-3 for proper operation.

Table 6-3. ALP Filter Parameters

Parameter	Recommendation
K-value	Set when the ALP filter is enabled
Proximity Positive Threshold	Set when the ALP filter is enabled
Proximity Negative Threshold	Set when the ALP filter is enabled

6.3.2.1 *ALP Filter Parameters*

6.3.2.1.1 K-Value

The K-value of the ALP filter determines the attenuation of noise in proximity sensor raw counts. The CY8CMBR3xxx controller has three different K-values: 1/16, 1/32, and 1/64.

Noise attenuation decreases in the order 1/64 > 1/32 > 1/16. Refer to the ALP Filter Tuning section to set this parameter.

6.3.2.1.2 Proximity Positive Threshold

This parameter determines the turn-on time of the proximity sensor, and is in the range 0-255; the default value is set to 30. Refer to the ALP Filter Tuning section to set this parameter.

6.3.2.1.3 Proximity Negative Threshold

This parameter determines the turn-off time of the proximity sensor, and is in the range 0-255; the default value is set to 30. Refer to the ALP Filter Tuning section to set this parameter.

6.3.2.2 *ALP Filter Tuning*

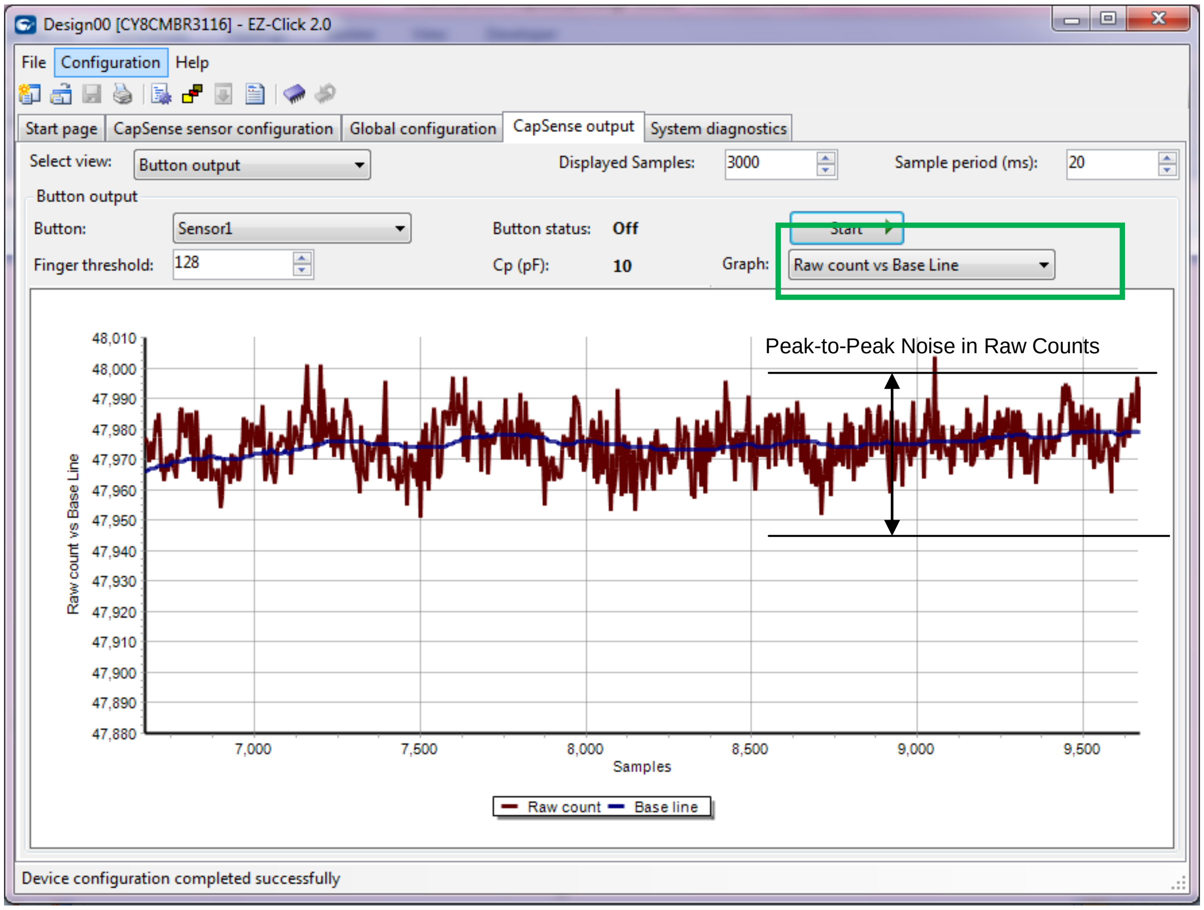
To tune the ALP filter, follow these steps:

1. Disable the ALP filter and measure the peak-to-peak noise in raw counts for 3000 samples, as Figure 6-7 shows. See the Noise Counts Measurement section for more details.
2. Set the K-value in the “CapSense sensor configuration” tab of EZ-Click per the mapping in Table 6-4.

Table 6-4. Selecting the K-Value

Peak-to-Peak Noise	Recommended K-Value
Less than 32 counts	1/16
Greater than 32 counts	1/32
Greater than 64 counts	1/64

Figure 6-7. Measuring Noise Counts of Proximity Sensor When ALP Filter is Disabled



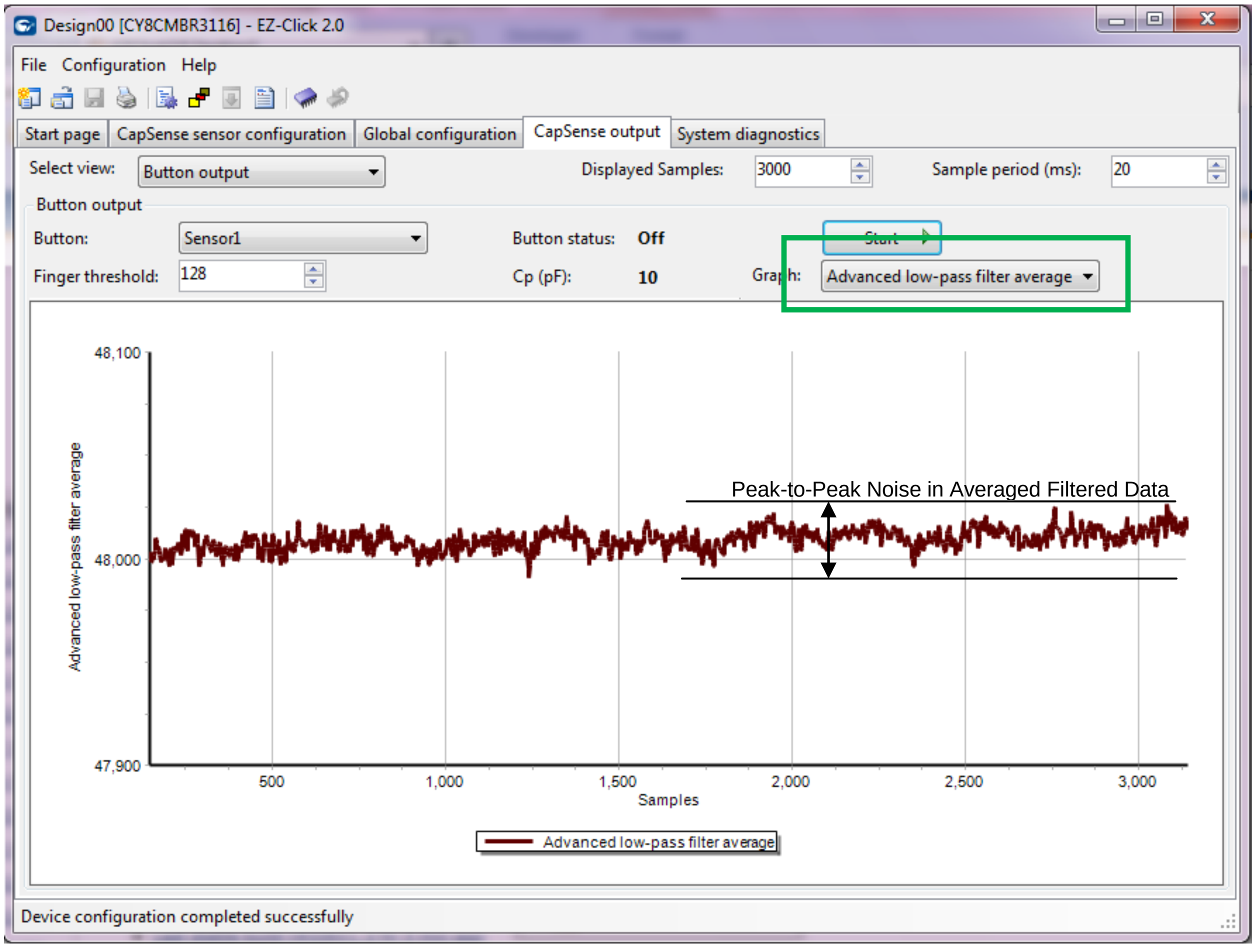
Select view: Button output
Displayed Samples: 3000
Sample period (ms): 20

Button output
Button: Sensor1
Button status: Off
Finger threshold: 128
Cp (pF): 10
Graph: Raw count vs Base Line

Device configuration completed successfully

3. Enable the ALP filter (If K-Value is set, EZ-Click automatically enables ALP filter) and measure the peak-to-peak noise in the advanced low pass average filtered data for 3000 samples, as Figure 6-8 shows. The average filtered data can be viewed in the CapSense output tab in EZ-Click.

Figure 6-8. Peak-to-Peak Noise in Average Filtered Data

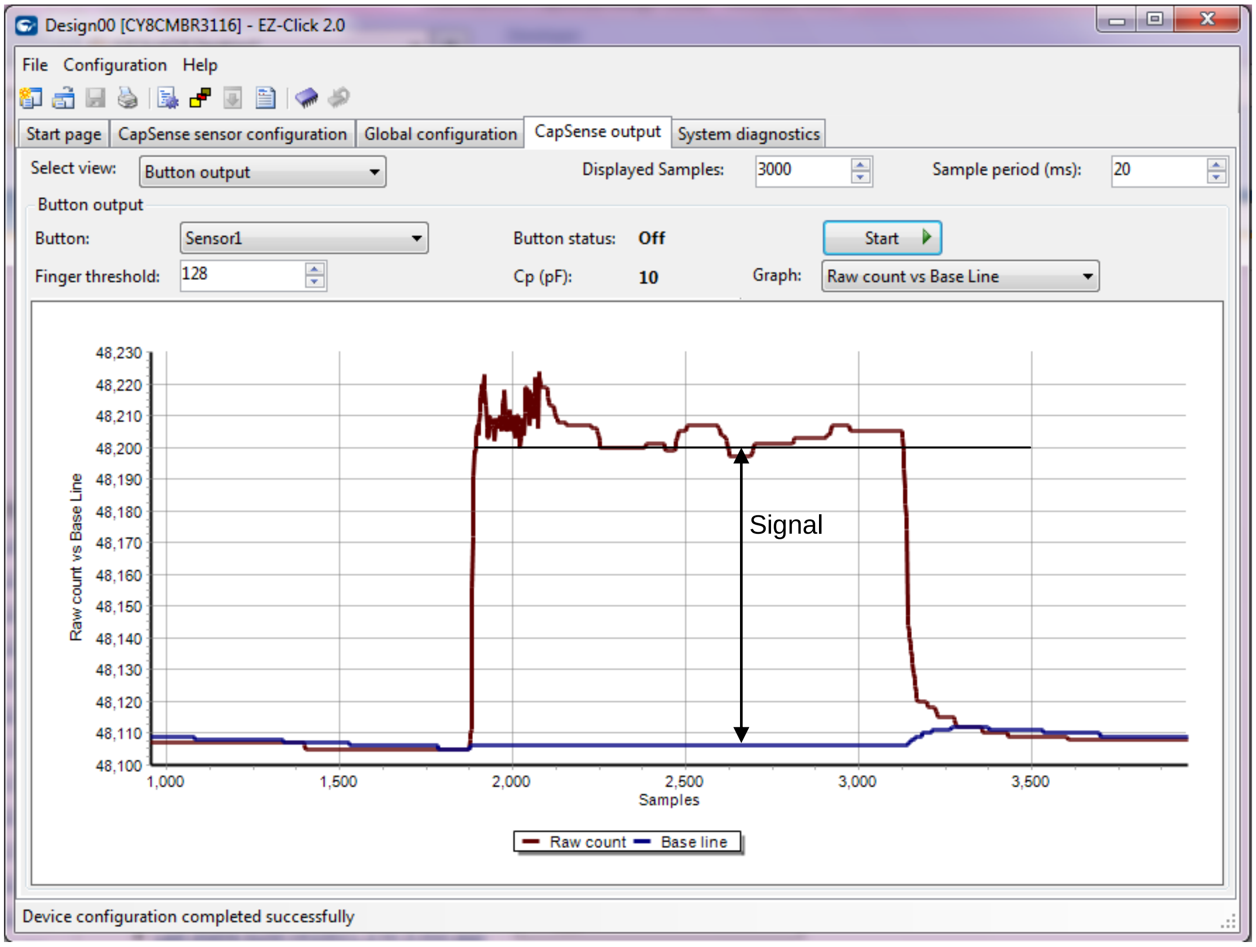


Select view: Button output
Displayed Samples: 3000
Sample period (ms): 20
Button output
Button: Sensor1
Button status: Off
Finger threshold: 128
Cp (pF): 10
Graph: Advanced low-pass filter average

Device configuration completed successfully

4. Set the proximity positive threshold as equal to 1.5 × peak-to-peak noise of the average filtered data.
5. Set the proximity negative threshold as equal to 0.5 × peak-to-peak noise of the average filtered data.
6. Set the finger threshold as equal to the proximity positive threshold. This is required to determine the response of the ALP filter.
7. Configure the device with these settings and measure the noise in raw counts.
8. Place the hand at the required proximity distance and measure the signal, as Figure 6-9 shows.
9. Compute the SNR. If the SNR is greater than 5:1, then proceed to set the thresholds, as per Table 6-5. Otherwise, increase the proximity resolution and repeat from Step 1.

Figure 6-9. Measuring Proximity Sensor Signal


Design00 [CY8CMBR3116] - EZ-Click 2.0

File Configuration Help

Start page | CapSense sensor configuration | Global configuration | CapSense output | System diagnostics

Select view: Button output

Displayed Samples: 3000

Sample period (ms): 20

Button output

Button: Sensor1

Button status: Off

Finger threshold: 128

Cp (pF): 10

Graph: Raw count vs Base Line

Device configuration completed successfully

6.3.3 Proximity Sensor Threshold Parameters

Table 6-5 lists the threshold parameters that are applicable to proximity sensors.

Table 6-5. Proximity Sensor Thresholds

Parameter	Recommendation
Proximity Threshold	Should always be set manually
Proximity Touch Threshold	Should always be set manually
Proximity Hysteresis	Set when hysteresis override is enabled
Proximity Noise Threshold	Set when Noise threshold override is enabled
Proximity Negative Noise Threshold	Set when Negative Noise threshold override is enabled
Proximity Low-Baseline Reset	Set when low baseline reset override is enabled

6.3.3.1 *Proximity Threshold*

The proximity threshold parameter is similar to the finger threshold of buttons. It determines the ON/OFF state of the proximity sensor. If the difference count is greater than proximity threshold + hysteresis, the proximity status is ON. If the difference count is less than proximity threshold - hysteresis, the proximity status is OFF. This threshold should be manually set. This parameter can range from 31 to 200; the default value is 128. See Table 6-6 for the recommended value.

6.3.3.2 *Proximity Touch Threshold*

A proximity sensor has two events: proximity detect event and touch detect event (upon physically touching the proximity sensor). The proximity threshold parameter determines the ON/OFF status of the proximity event; the proximity touch threshold is used to detect the touch event of the proximity sensor. This parameter can range from 62 to 65000; the default value is 512. See Table 6-6 for the recommended value.

6.3.3.3 *Proximity Hysteresis*

The proximity hysteresis parameter is similar to button hysteresis. It is used along with the proximity threshold parameter to determine the ON/OFF status of the proximity sensor. This parameter can range from 0 to 127; the default value is 5. See Table 6-6 for the recommended value.

6.3.3.4 *Proximity Noise Threshold*

The proximity noise threshold parameter is similar to the Noise Threshold parameter for buttons. This parameter can range from 0 to 127; the default value is 20. See Table 6-6 for the recommended value.

6.3.3.5 *Proximity Negative Noise Threshold*

The proximity negative noise threshold parameter is similar to the Negative Noise Threshold parameter for buttons. This parameter can range from 0 to 127; the default value is 20. See Table 6-6 for the recommended value.

6.3.3.6 *Proximity Low-Baseline Reset*

The proximity low-baseline reset parameter is similar to the Low-Baseline Reset parameter for buttons. This parameter can range from 0 to 127; the default value is 50. See Table 6-6 for the recommended value.

6.3.4 Setting Proximity Sensor Threshold Parameters

For a proximity sensor, only the proximity threshold and proximity touch threshold need to be specified. All other thresholds will be internally calculated by the SmartSense algorithm.

If, for some reason, these parameters need to be overridden, use the Bridge Control Panel to send I^{2}C commands to override these parameters. Refer to the *CY8CMBR3xxx Registers TRM* for more details. It is strongly recommended not to override threshold parameters.

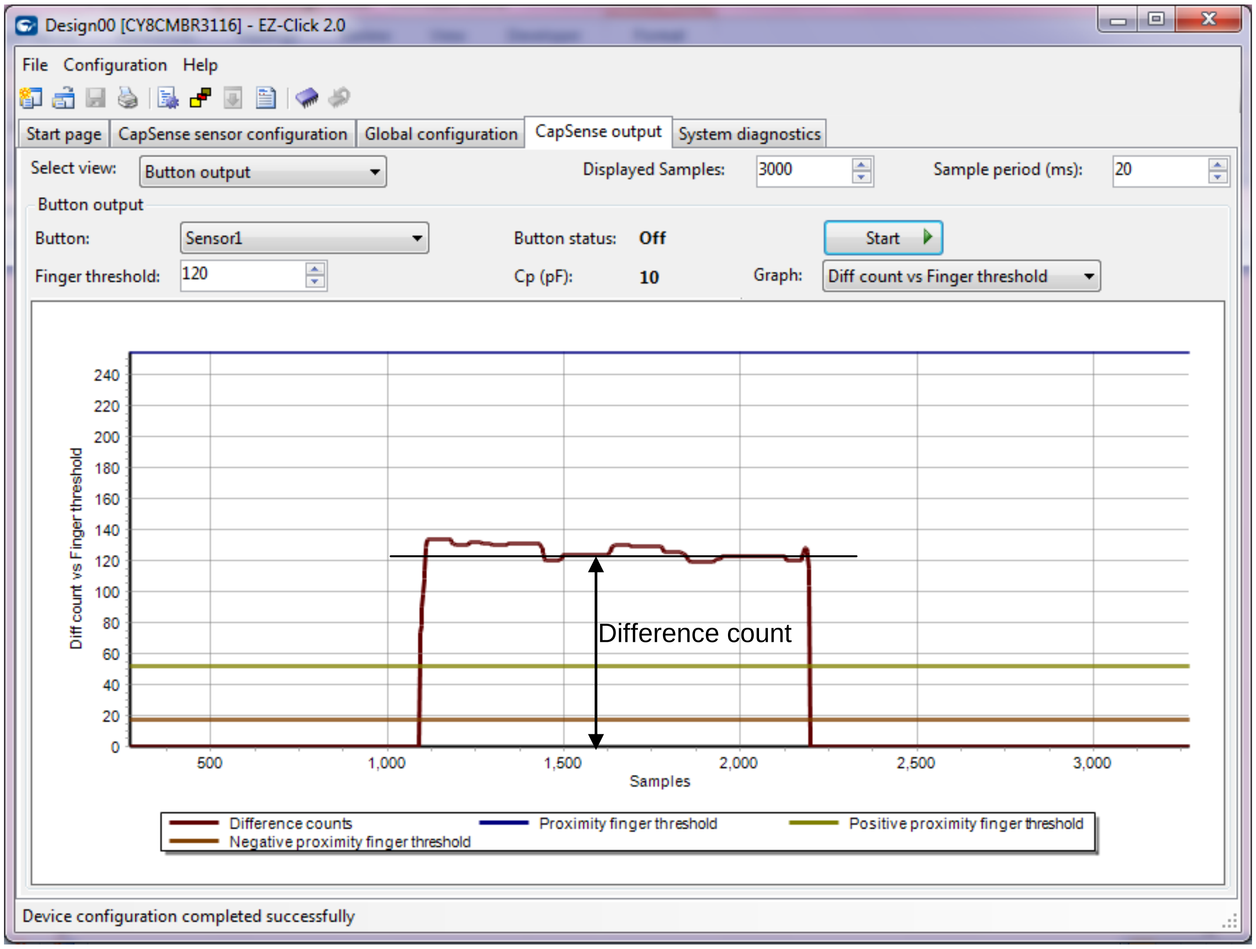
Follow the below procedure to set the threshold parameters for a proximity sensor:

1. In the CapSense output tab, select the Diff count vs. Finger threshold graph for proximity sensor and click on the Start button.
2. Place the hand at the required proximity distance and measure the difference count, as shown in Figure 6-10.
   Notes:
   - The difference count in CY8CMBR3xxx controller is normalized. It will not be equal to
     Raw counts (touched) - Baseline.
   - If the difference count is greater than 255, it will be truncated to 255. In this case, threshold parameters cannot be set properly. Increase the sensitivity parameter value until the difference counts is less than 255. Ensure the SNR is greater than 5:1 after changing the sensitivity parameter value.
3. Set the threshold parameters to values as shown in Table 6-6.
4. To set the proximity touch threshold, touch the proximity sensor and measure the difference counts (Proximity Sensor Touched).
5. Set the proximity touch threshold to a value equal to 80% of difference counts (Proximity Sensor Touched)

Table 6-6. Proximity Threshold Settings

Threshold Parameter	Recommendation
Proximity Threshold	80% of Difference count
Proximity Touch Threshold	80% of Difference count (when proximity sensor is touched)
Proximity Noise Threshold	40% of Difference count
Proximity Negative Noise Threshold	40% of Difference count
Proximity Hysteresis	10% of Difference count
Proximity Low-Baseline Reset	Set to 50

Figure 6-10. Measuring Difference Count to Set Proximity Sensor Thresholds


Design00 [CY8CMBR3116] - EZ-Click 2.0
File
Configuration
Help
Start page
CapSense sensor configuration
Global configuration
CapSense output
System diagnostics
Start
240
220
200
180
160
140
120
100
80
60
40
20
0
500
1,000
1,500
2,000
2,500
3,000
Samples
Diff count vs Finger threshold
Difference count
Difference counts
Proximity finger threshold
Positive proximity finger threshold
Negative proximity finger threshold

Select view: Button output
Displayed Samples: 3000
Sample period (ms): 20
Button output
Button: Sensor1
Button status: Off
Finger threshold: 120
Cp (pF): 10
Graph: Diff count vs Finger threshold

Device configuration completed successfully

7. Low-Power Design Considerations

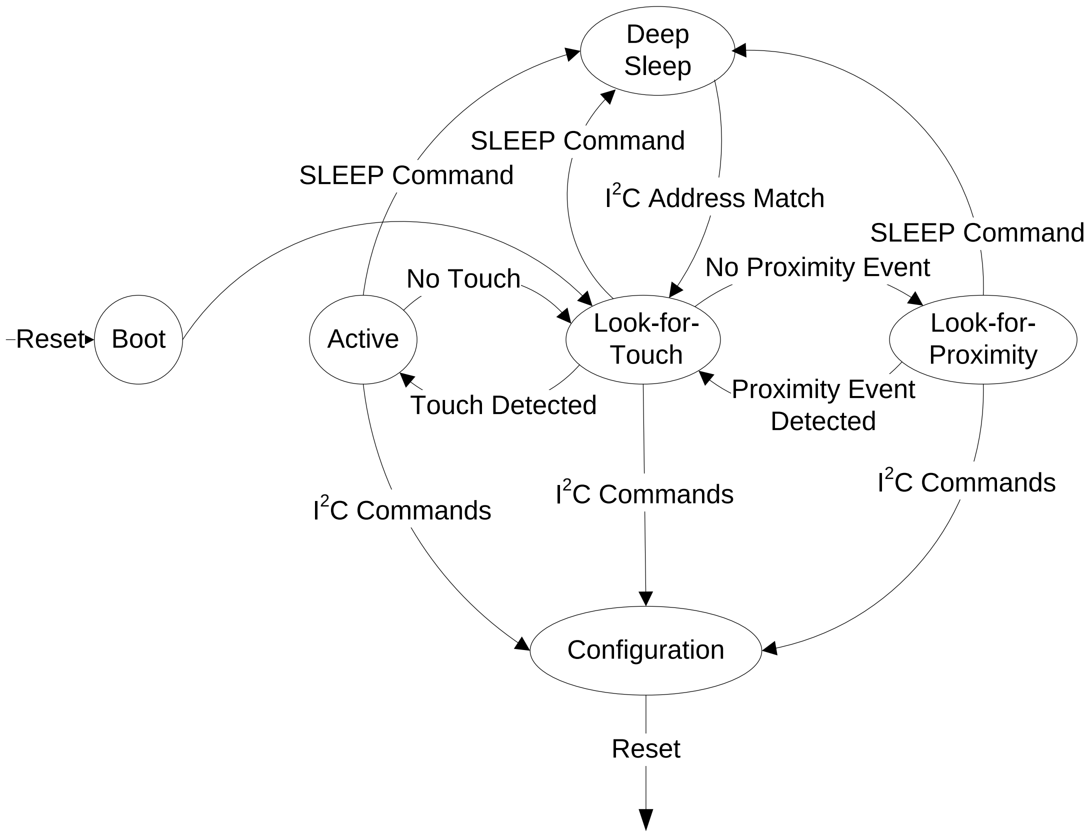
Capacitive touch sensing is used in battery-powered, handheld, and portable electronic devices. Because these devices are battery powered, power consumption and energy efficiency become very important. This section explains the factors that affect the power consumption of the CY8CMBR3xxx controller and provides guidelines on how to minimize the power consumption.

7.1 CY8CMBR3xxx Operating Modes

The CY8CMBR3xxx controller supports five operational modes:

1. Active Mode
2. Look-for-Touch Mode
3. Look-for-Proximity Mode
4. Deep Sleep Mode
5. Configuration Mode

Figure 7-1. CY8CMBR3xxx Operational Modes



7.1.1 Active Mode

The CY8CMBR3xxx controller enters the Active mode from the reset state, as Figure 7-1 shows. In Active mode, the controller scans all the sensors, updates the sensor data, and drives any configured outputs (GPOs, buzzer, and host interrupt) based on the sensor status. By default, the scan rate during the Active mode is set to 20 ms to ensure fast touch response. If the sensor scanning and processing is completed within 20 ms, then the controller is put to the sleep mode for the time duration equal to (20 ms – Active time). When the 20 ms timer expires, sensors are scanned again and the cycle continues, as Figure 7-2 shows.

If the time taken to scan all the sensors and process the sensor data is more than 20 ms, then the device is not put in to the sleep mode. Instead, the next cycle of scanning will be started, as Figure 7-3 shows.

Figure 7-2. Active Mode Scan-Sleep Sequence When Active Time < 20 ms

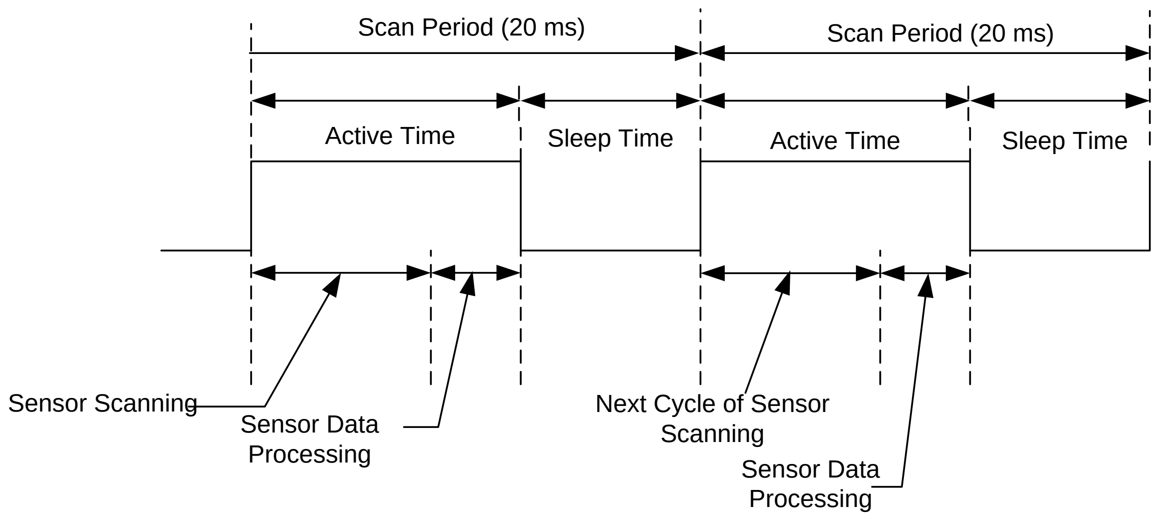
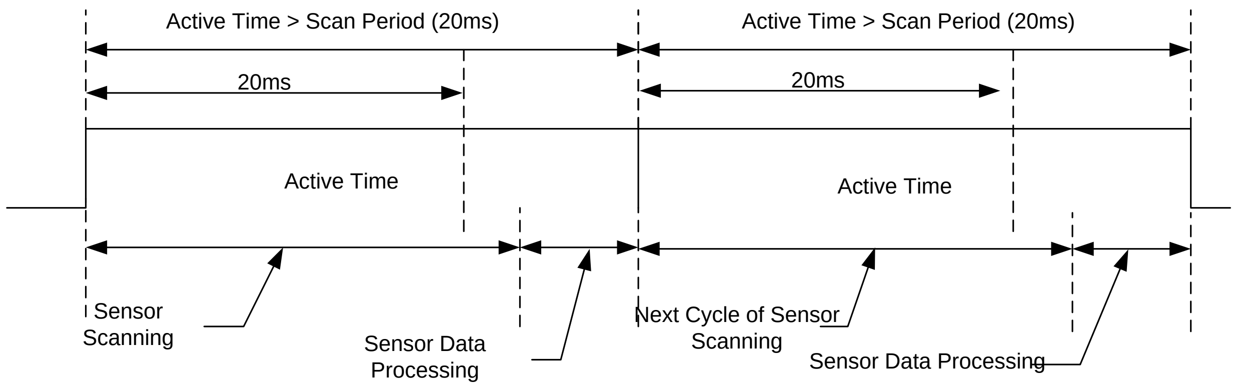


Figure 7-3. Active Mode Scan-Sleep Sequence When Active Time > 20 ms


Active Time > Scan Period (20ms)
Active Time > Scan Period (20ms)
20ms
20ms
Active Time
Active Time
Sensor Scanning
Sensor Data Processing
Next Cycle of Sensor Scanning
Sensor Data Processing

7.1.2 Look-for-Touch Mode

If no touch is detected in the Active mode for duration equal to the State Timeout value, CY8CMBR3xxx enters the Look-for-Touch mode, as Figure 7-1 shows. The Look-for-Touch mode is similar to the Active mode except that the scan period is configurable. The default value of scan period is 120 ms. In this mode, all the sensors are scanned and sensors data are processed. If any sensor is ON, outputs (GPOs, buzzer and host interrupt) are driven and the controller enters the Active mode.

7.1.3 Look-for-Proximity Mode

The Look-for-Proximity mode is applicable only if the design has proximity sensor and Wake-on-Approach is enabled. If no touch is detected in the Look-for-Touch mode for a duration greater than or equal to the State Timeout value, then the controller enters the Look-for-Proximity mode, as Figure 7-1. shows.

In the Look-for-Proximity mode, the controller scans only proximity sensors. If a proximity event is detected, then the controller enters the Look-for-Touch mode. If a touch event is detected in the Look-for-Proximity mode, then the controller enters the Active mode. The scan period in this mode is configurable and it is equal to scan period in Look-for-Touch mode; the default value is 120 ms.

7.1.4 Deep Sleep Mode

The Deep Sleep mode is the lowest power consumption mode. The CY8CMBR3xxx device enters deep sleep mode when the host issues a sleep command. Refer to the CTRL_CMD register in the CY8CMBR3xxx Registers TRM for more details. In the deep sleep mode, the device doesn’t scan any sensor and all outputs are disabled. The device wakes up on I^{2}C address match event; NACKs the first I^{2}C command, and then enters the Look-for-Touch mode.

7.1.5 Configuration Mode

The device enters the configuration mode when CMD_OP_CODE = ‘2’ is written to CTRL_CMD register to save the configuration data to nonvolatile memory. Refer to CY8CMBR3xxx Registers TRM for more details. The device comes out of the configuration mode only through a device reset (either software or hardware reset).

7.2 Factors Affecting Power Consumption

Various factors that affect power consumption of the CY8CMBR3xxx controller are:

- **Number of Sensors:** The total scan time of sensors increases with the increase in the number of sensors. For a fixed scan period, if the scan time increases, then the duration in which the device is in sleep mode decreases. This results in increased power consumption of the device.
- **C_P of the Sensor:** This affects the scan time of the sensor. With a larger value of C_P, there will be higher sensor scan time, which results in increased power consumption. Follow the layout guidelines mentioned in the *Getting Started with CapSense* guide to minimize the sensor C_P.
- **Sensitivity:** This parameter affects the scan time of the sensor. The scan time of the sensor increases with a decrease in the sensor sensitivity parameter value. As a result, the lower the sensitivity parameter value, the higher will be the power consumption.

  The power consumption decreases in the order 100 fF > 200 fF > 300 fF > 400 fF.
- **Electromagnetic Compatibility (EMC):** When the EMC feature is enabled, the scan time of the sensor increases and results in increased power consumption.
- **Buzzer Duration:** The CY8CMBR3xxx controller stays in the active state while driving the buzzer output. Longer buzzer duration results in increased active time and higher power consumption.
- **PWM on GPOs:** Enabling PWM on GPOs has the same effect as that of enabling the buzzer output. If PWM output is enabled on the GPO pins, the device is not put into sleep mode and this increases the power consumption.
- **Scan period:** The scan period parameter affects the duration for which the device is in sleep mode. The higher the scan period, the lower will be the power consumption.
- **State Timeout:** The state timeout parameter affects how quickly the device enters the look-for-touch mode from the active mode or the look-for-proximity mode from the look-for-touch mode. The shorter the state timeout interval, the lower will be the power consumption.
- **I^{2}C Communication:** As explained in the Active Mode section, CY8CMBR3xxx enters sleep mode after the sensor scanning is completed. The CY8CMBR3xxx will not enter sleep mode or it will exit from deep sleep mode if there are any I^{2}C transactions with the host processor. Therefore frequent I^{2}C transactions result in increased average power consumption.

  To reduce the average power consumption, implement a dedicated host interrupt pin and initiate I^{2}C transaction only when the CY8CMBR3xxx sends a host interrupt pulse.

Use the CY8CMBR3xxx Design Toolbox to estimate the average current consumption of the controller based on the design inputs as explained in Estimating the Average Current section.

7.3 System Design Recommendations for Low Power Consumption

Cypress's CY8CMBR3xxx is designed to meet the low-power requirements of battery-powered applications. To minimize power consumption, follow these guidelines:

- Minimize the sensor C_P using the design guidelines mentioned in Getting Started with CapSense and CY8CMBR3xxx Design Toolbox.
- Set optimum value of sensitivity for sensors. Refer to the Sensitivity Control section.
- Enable EMC only if required. Refer to the Electromagnetic Compatibility (EMC) section.
- Increase the scan period and decrease the state timeout period.
- Put the device in to deep sleep mode or turn off the power to the device using the power manager IC (PMIC) when sensor scanning is not required.
- Avoid frequent I^2C reads/writes to the CY8CMBR3xxx controller. Use host interrupt pin and initiate I^2C transaction only after the CY8CMBR3xxx sends a host interrupt pulse.
- Use the proximity sensor and enable the wake-on-approach feature.
- Reduce the Buzzer ON time duration.
- Enable PWM on GPOs only if required.

8. Resources

8.1 Website

Visit the Cypress's CapSense Controllers website to access the reference material discussed in this document.

You can find a variety of technical resources on the CY8CMBR3xxx web page.

8.2 Datasheet

The datasheet for the CapSense CY8CMBR3xxx device is available at CY8CMBR3xxx Datasheet

8.3 Registers Technical Reference Manual

The registers technical reference manual is available at CY8CMBR3xxx Registers TRM

8.4 Design Toolbox

The interactive Design Toolbox enables you to design a robust and reliable CY8CMBR3xxx CapSense solution.

8.5 EZ-Click™ 2.0

EZ-Click 2.0 is a simple, GUI-based software utility that can be used to customize CY8CMBR3xxx device configurations.

8.6 Development Kit

The CY3280-MBR3 Evaluation Kit is designed to showcase the abilities of the CY8CMBR3116 CapSense Controller. Use this kit to quickly evaluate the features of CY8CMBR3xxx solution.

8.7 Design Support

Cypress has a variety of design support channels to ensure the success of your CapSense solutions.

Knowledge-Based Articles –Browse technical articles by product family or search on CapSense topics.

CapSense Application Notes – Peruse a wide variety of application notes built on information presented in this document.

White Papers – Learn about advanced capacitive touch interface topics.

Cypress Developer Community – Connect with the Cypress technical community and exchange information.

CapSense Product Selector Guide – See the complete CapSense product line.

Video Library –Get up to speed quickly with tutorial videos

Quality & Reliability – Cypress is committed to customer satisfaction. At our Quality website, find reliability and product qualification reports.

Technical Support – World-class technical support is available online.

9. Appendix

9.1 High-Level APIs

Table 9-1. High-Level Host APIs

1	**CY8CMBR3xxx_ReadSensorStatus**	
	Description	This API reads the button status, latched button status, proximity status, latched proximity status, slider 1 and 2 positions, and slider 1 and 2 liftoff positions from the CY8CMBR3xxx device. The slider positions and slider liftoff positions are valid for CY8CMBR3106S device only. You can use this API when the device asserts a Host Interrupt pulse, to understand the corresponding status change.
	Prototype	bool CY8CMBR3xxx_ReadSensorStatus(uint8 slaveAddress, CY8CMBR3XXX_SENSORSTATUS *status)
	Parameters	slaveAddress The I^{2}C address of the CY8CMBR3xxx device. Valid range: 8 – 119
		*status Pointer to the user-defined buffer where the sensor status read from the CY8CMBR3xxx device is stored. The buffer structure is defined in CY8CMBR3xxx_APIs.h.
	Return value	TRUE – If the buffer was updated properly FALSE – If the buffer was not updated
2	**CY8CMBR3xxx_WriteData**	
	Description	This API writes one or more bytes of data to successive register locations in the CY8CMBR3xxx device. The initial register location is user specified.
	Prototype	bool CY8CMBR3xxx_WriteData(uint8 slaveAddress, uint8 *writeBuffer, uint8 numberOfBytes)
	Parameters	SlaveAddress The I^{2}C address of the CY8CMBR3xxx device. Valid range: 8 – 119

		*writeBuffer The buffer from which data is written to the device. The first element should always contain the location of the register of the device to write to. This value can be within 0 – 134. Each successive element should contain the data to be written to that register and the successive registers. These elements can have a value between 0 – 255. The number of data bytes can be between 1 to minimum of (128, and 135 – register location).
		numberOfBytes Number of bytes to be written, equal to the number of elements in the buffer. Valid range: 1 – min(129, 136 – register location)
	Return value	TRUE – If the write was successful FALSE – If the write was not successful
3	**CY8CMBR3xxx_ReadData**	
	Description	This API reads one or more bytes of data from successive register locations in the CY8CMBR3xxx device. The initial register location is user specified.
	Prototype	bool CY8CMBR3xxx_ReadData(uint8 slaveAddress, uint8 registerAddress, uint8 *readBuffer, uint8 numberOfBytes)
	Parameters	slaveAddress The I^{2}C address of the CY8CMBR3xxx device. Valid range: 8 – 119
		registerAddress The register location to read from. The value passed to this argument should be one of the register offset macros defined in the file CY8CMBR3xxx_Registers.h. The macro for a register is defined only if it is supported by the device defined by CY8CMBR3xxx_DEVICE macro.
		*readBuffer The buffer to be updated with the data read from the device. Each successive element to contain the data read from successive registers. These elements can have a value between 0 – 255.
		numberOfBytes Number of bytes to be read, equal to the number of elements in the buffer. Valid range: 1 – 252
	Return value	TRUE – If the read was successful FALSE – If the read was not successful
4	**CY8CMBR3xxx_WriteDualByte**	
	Description	This API writes to a two byte register in the CY8CMBR3xxx device. The register location is user – specified.

	Prototype	bool CY8CMBR3xxx_WriteDualByte(uint8 slaveAddress, uint8 registerAddress, uint16 writeData)
	Parameters	slaveAddress The I^2C address of the CY8CMBR3xxx device. Valid range: 8 – 119
		registerAddress The register location to write to. The value passed to this argument should be one of the register offset macros defined in the file CY8CMBR3xxx_Registers.h. The macro for a register is defined only if it is supported by the device defined by CY8CMBR3xxx_DEVICE macro.
		writeData The two-byte value to be written to the register. The LSB forms the first byte and the MSB forms the second byte. Valid range: 0 – 65535
	Return value	TRUE – If the write was successful FALSE – If the write was not successful
5	**CY8CMBR3xxx_ReadDualByte**	
	Description	This API reads from a two-byte register in the CY8CMBR3xxx device and updates the concatenated value to the read buffer. The register location is user – specified.
	Prototype	bool CY8CMBR3xxx_ReadDualByte(uint8 slaveAddress, uint8 registerAddress, uint16 *readData)
	Parameters	slaveAddress The I^2C address of the CY8CMBR3xxx device. Valid range: 8 – 119
		registerAddress The two-byte register to read from. The data will be read from this address and the successive address. The value passed to this argument should be one of the register offset macros defined in the file CY8CMBR3xxx_Registers.h. The macro for a register is defined only if it is supported by the device defined by CY8CMBR3xxx_DEVICE macro.
		*readData The 2-byte buffer to be updated with the value read from the device. The API fills the LSB with the first byte read from the device and the MSB with the second byte. The value can be between 0 – 65535.
	Return value	TRUE – If the read was successful FALSE – If the read was not successful

6	**CY8CMBR3xxx_SendCommand**	
	Description	This API issues a new command to the CY8CMBR3xxx device. Before calling this API, you should check whether the device is ready to accept a new command by calling CY8CMBR3xxx_CheckCommandStatus().
	Prototype	bool CY8CMBR3xxx_SendCommand(uint8 slaveAddress, uint8 command)
	Parameters	slaveAddress The I^{2}C address of the CY8CMBR3xxx device. Valid range: 8 - 119
		command The command op-code to issue. The value passed to this argument should be one of the op-code macros defined in the file CY8CMBR3xxx_CommandsAndConfig.h.
	Return value	TRUE – If the command was issued successfully FALSE – If the command was not issued successfully
7	**CY8CMBR3xxx_CheckCommandStatus**	
	Description	This API verifies whether the CY8CMBR3xxx device is ready to accept a new command, and whether the previously issued command has executed successfully.
	Prototype	uint8 CY8CMRB3xxx_CheckCommandStatus(uint8 slaveAddress, uint8 *errorCode)
	Parameters	slaveAddress The I^{2}C address of the CY8CMBR3xxx device. Valid range: 8 - 119
		*errorCode Pointer to the error code returned from the last command execution. If the last command failed, the API updates this data to show what caused the failure. Valid range is 0 to 255.
	Return value	0 – If the last command is still executing 1 – If the last command executed successfully 2 – If the last command did not execute successfully, or if the I^{2}C communication failed.
8	**CY8CMBR3xxx_Configure**	
	Description	This API writes a user – specified configuration to the CY8CMBR3xxx device, saves the configuration, and resets the device. To configure the device, you should first create a configuration using EZ-Click. The 128-byte configuration data (generated in the project specific .h file in the EZ-Click project) should be used directly for this API. This API blocks CPU execution during the configuration save command execution, and during CY8CMBR3xxx device reset.
	Prototype	bool CY8CMBR3xxx_Configure(uint8 slaveAddress, const unsigned char *configuration)

	Parameters	slaveAddress The I²C address of the CY8CMBR3xxx device. Valid range: 8 – 119
		*configuration Buffer of 128 bytes to store the entire configuration for the device. This data should be taken directly from the EZ-Click generated configuration data. This includes 126-bytes of configuration registers data and two bytes of CRC.
	Return value	TRUE – If the device was configured successfully FALSE – If the device was not configured successfully
9	**CY8CMBR3xxx_CalculateCrc**	
	Description	This API calculates the CRC checksum of a given configuration setting for the CY8CMBR3xxx device.
	Prototype	uint16 CY8CMBR3xxx_CalculateCrc(uint8 *configuration)
	Parameters	*configuration This 126-byte buffer would hold the entire configuration setting for the device.
	Return value	A two-byte value (with the higher byte being the MSB) for the calculated CRC.
10	**CY8CMBR3xxx_VerifyDeviceOnBus**	
	Description	This API verifies that the device on the I²C bus is a valid CY8CMBR3xxx device. It checks the Device ID, Family ID, and Device Revision to verify the device.
	Prototype	bool CY8CMBR3xxx_VerifyDeviceOnBus(uint8 slaveAddress)
	Parameters	slaveAddress The I²C address of the CY8CMBR3xxx device. Valid range: 8 – 119
	Return value	TRUE – if the device is valid FALSE – if the device is not valid
11	**CY8CMBR3xxx_SetDebugDataSensorId**	
	Description	This API sets the Sensor ID for reading the corresponding debug data from the CY8CMBR3xxx device. To read the debug data from the device, you should first call this API, followed by a time wait equal to the device refresh interval. Then you should call CY8CMBR3xxx_ReadSensorDebugData() to read back the debug data from the device.
	Prototype	bool CY8CMBR3xxx_SetDebugDataSensorId(uint8 slaveAddress, uint8 sensorId)

	Parameters	SlaveAddress The I^{2}C address of the CY8CMBR3xxx device. Valid range: 8 – 119
		sensorId The sensor number for which the data is requested. This number can be a maximum of one less than the total number of sensors supported by the device.
	Return value	TRUE – If the sensor ID write operation was successful FALSE – If the sensor ID write operation was not successful
12	**CY8CMBR3xxx_ReadSensorDebugData**	
	Description	This API reads the Cp, Difference counts, Baseline, Raw counts, and Average Raw counts of a sensor and updates the data to a buffer. To read debug data, you should first call CY8CMBR3xxx_SetDebugDataSensorId(), and then wait for one refresh interval. After this time, you should call this API to read the data from the device. The API updates the buffer only if the sync counters of the device match. In case they don't, the API tries to read the data again. The maximum number of read attempts is defined by CY8CMBR3xxx_SYNC_COUNTER_MATCH_RETRY. You can set this value in CY8CMBR3xxx_APIs.h file.
	Prototype	bool CY8CMBR3xxx_ReadSensorDebugData(uint8 slaveAddress, CY8CMBR3XXX_SENSORDATA *debugData)
	Parameters	slaveAddress The I^{2}C address of the CY8CMBR3xxx device. Valid range: 8 – 119
		*debugData Pointer to the user-defined buffer where the data read from the CY8CMBR3xxx device is stored. The buffer structure is defined in CY8CMBR3xxx_APIs.h.
	Return value	TRUE – If the buffer was updated properly FALSE – If the buffer was not updated
13	**CY8CMBR3xxx_ReadDiffCounts**	
	Description	This API reads the Difference counts of all sensors of the CY8CMBR3xxx device and updates the data to a buffer. The API updates the buffer only if the sync counters of the device match. In case they don't, the API tries to read the data again. The maximum number of read attempts is defined by CY8CMBR3xxx_SYNC_COUNTER_MATCH_RETRY. You can set this value in CY8CMBR3xxx_APIs.h file.
	Prototype	bool CY8CMBR3xxx_ReadDiffCounts(uint8 slaveAddress, uin16 *differenceCounts)
	Parameters	slaveAddress The I^{2}C address of the CY8CMBR3xxx device. Valid range: 8 – 119

		*differenceCounts Buffer to store the difference counts of all sensors. The buffer size should be equal to the number of sensors in the device.
	Return value	TRUE – If the buffer was updated properly FALSE – If the buffer was not updated

9.2 Low-Level APIs

Table 9-2. Low-Level Host APIs

1	**Host_LowLevelWrite**	
	Description	This API writes to the register map of the CY8CMBR3xxx device using the I^{2}C communication protocol. The implementation is host processor dependent and requires modification to the API code to suit specific host processor. In case the device NACKs I^{2}C transaction on the first time, ensure that this API retries twice within the next 340 ms.
	Prototype	bool Host_LowLevelWrite(uint8 slaveAddress, uint8 *writeBuffer, uint8 numberOfBytes)
	Parameters	SlaveAddress The I^{2}C address of the CY8CMBR3xxx device. Valid range: 8 – 119
		*writeBuffer The buffer from which data is written to the device. The first element should always contain the location of the register of the device to write to. This value can be within 0 – 251. Each successive element should contain the data to be written to that register and the successive registers. These elements can have a value between 0 – 255. The number of data bytes can be between 0 and 128. Writing zero data bytes signifies that you are updating the register location from which you want to read device register map information.
		numberOfBytes Number of bytes to be written, equal to the number of elements in the buffer (i.e. number of data bytes + 1 for register location)
	Return value	TRUE – If the write process was successful FALSE – If the write process was not successful
2	**Host_LowLevelRead**	
	Description	This API reads from the register map of the CY8CMBR3xxx device using the I^{2}C communication protocol. The implementation is host processor dependent and requires modification to the API code to suit specific host processor. In case the device NACKs I2C transaction on the first time, you must ensure that this API retries twice within the next 340 ms.

	Prototype	bool Host_LowLevelRead(uint8 slaveAddress, uint8 *readBuffer, uint8 numberOfBytes)
	Parameters	slaveAddress The I^{2}C address of the CY8CMBR3xxx device. Valid range: 8 – 119
		*readBuffer The buffer to be updated with the data read from the device. The register location to read from should be set using Host_LowLevelWrite API prior to calling this API. Each successive element to contain the data read from that register and the successive registers. These elements can have a value between 0 – 255.
		numberOfBytes Number of data bytes to be read, equal to the buffer size. Valid range: 1 – 252
	Return value	TRUE – If the read process was successful FALSE – If the read process was not successful
3	**Host_LowLevelDelay**	
	Description	This API implements a time-delay function to be used by the High-level APIs. The delay period is in milliseconds. This delay is achieved by a code-execution block for the required amount of time. The implementation is host processor dependent and requires modification to the API code to suit your host.
	Prototype	void Host_LowLevelDelay(uint16 milliseconds)
	Parameters	milliseconds The amount of time in milliseconds for which a wait is required. Valid range: 0 – 65535
	Return value	None

Revision History

Document Revision History

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Revision	Issue Date	Origin of Change	Description of Change
**	02/18/2014	DCHE	New Design Guide
*A	02/25/2014	DCHE/UDYG	Modified Figure 1-2 and Figure 2-13 Added Min and Max Cp range for each sensors in Table 4-1 Updated section 5.2 with Host APIs and Bridge Control Panel Added Appendix chapter
*B	03/11/2014	DCHE	Updated the Operating Voltage Specifications
*C	06/05/2014	DCHE	Added footnote#6 in page 27 Updated MBR3 Design Toolbox with Device Timing Parameters Table Updated "Estimating the Response Time" section with Device Timing Parameters.