

## Features

- Easy to use capacitive button controller
  - Ten-button solution configurable through Hardware straps
  - No software tools or programming required
  - Ten general-purpose outputs (GPO)
  - GPOs linked to CapSense buttons
  - GPOs support direct LED drive
- SmartSense™ Auto-Tuning
  - Maintains optimal button performance even in noisy environment
  - CapSense parameters dynamically set in runtime
  - Saves time and effort in device tuning
  - Wide parasitic capacitance ( $C_p$ ) range (5 pF–40 pF)
- Noise Immunity
  - Specifically designed for superior noise immunity to external radiated and conducted noise
  - Low radiated noise emission
- System Diagnostics of CapSense buttons - reports faults at device power up
  - Button shorts
  - Improper value of modulator capacitor ( $C_{MOD}$ )
  - Out of range  $C_p$  value
- Advanced features
  - Robust sensing even with closely spaced buttons - flanking sensor suppression (FSS)
  - User-configurable LED Effects
    - On-system power-on
    - LED ON Time after button release
  - Supports analog voltage output (requires external resistors)
  - Serial Debug Data output
    - Simplifies production-line testing and system debug
- Wide operating voltage range
  - 1.71 V to 5.5 V – ideal for both regulated and unregulated battery applications
- Low power consumption
  - Average current consumption of 21  $\mu$ A<sup>[1]</sup> per button
  - Deep sleep current: 100 nA

■ Industrial temperature range: –40 °C to +85 °C

■ 32-pin Quad Flat No leads (QFN) package  
(5 mm × 5 mm × 0.6 mm)

## Functional Description

The CY8CMBR2010 CapSense Express™ capacitive touch sensing controller saves time and money, quickly enabling a capacitive touch sensing user interface in your design. It is a hardware-configurable device and does not require any software tools, firmware coding, or device programming. This device is enabled with Cypress's revolutionary SmartSense™ Auto-Tuning algorithm. SmartSense™ Auto-Tuning ends the need to manually tune the user interface during development and production ramp. This speeds the time to volume and saves valuable engineering time, test time and production yield loss.

The CY8CMBR2010 CapSense controller supports up to ten capacitive touch sensing buttons and ten General Purpose Outputs (GPO). The GPO is an active low output controlled directly by the CapSense input making it ideal for a wide variety of consumer, industrial, and medical applications. The wide operating range of 1.71 V to 5.5 V enables unregulated battery operation, further saving component cost. The same device can also be used in different applications with varying power supplies.

This device supports ultra low-power consumption in both run mode and deep sleep modes to stretch battery life. In addition, this device also supports many advanced features which enhance the robustness and user interface of the end solution. Some of the key advanced features include Noise Immunity and FSS. Noise Immunity improves the immunity of the device against radiated and conducted noise, such as audio and radio frequency (RF) noise. FSS provides robust sensing even with closely spaced buttons. FSS is a critical requirement in small form factor applications.

Power-on LED effects provide a visual feedback to the design at power-on. This improves the aesthetic value of the end product. System Diagnostics test for design faults at power-on and report any failures. This simplifies production line testing and reduces manufacturing costs. Serial Debug data output gives the critical information about the design, such as button  $C_p$  and signal-to-noise ratio (SNR). This further helps in production line testing.

### Note

1. 21  $\mu$ A per button (4-buttons used, 3% touch time, 10 pF <  $C_p$  of all buttons < 20 pF, Button Scan Rate = 556 ms, with power consumption optimized, Noise Immunity level "Normal", CS0 sensitivity "High").

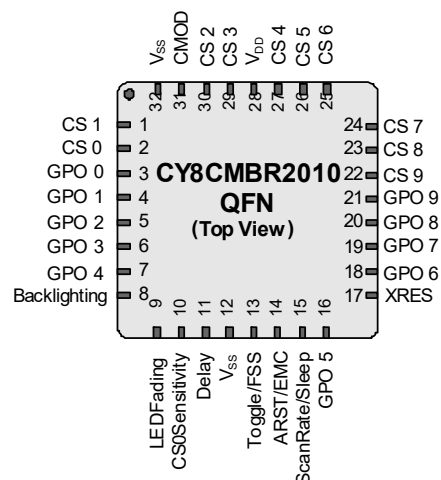
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## Pinout

**Table 1. Pin Diagram and Definitions – CY8CMBR2010**

| Pin | Label            | Type <sup>[2]</sup> | Description  | If Unused  |
|-----|------------------|---------------------|--|------------|
| 1   | CS1              | AI                  | CapSense button input, controls GPO1   | Ground     |
| 2   | CS0              | AI                  | CapSense button input, controls GPO0   | Ground     |
| 3   | GPO0             | DO                  | GPO activated by CS0   | Leave open |
| 4   | GPO1             | DO                  | GPO activated by CS1   | Leave open |
| 5   | GPO2             | DO                  | GPO activated by CS2   | Leave open |
| 6   | GPO3             | DO                  | GPO activated by CS3   | Leave open |
| 7   | GPO4             | DO                  | GPO activated by CS4   | Leave open |
| 8   | Backlighting     | DO                  | GPO controlled by CS0–CS9 when analog output voltage is enabled                      | Leave open |
| 9   | LED Fading       | AI                  | Controls the Power-on LED effects and Analog Voltage Output                          | Leave open |
| 10  | CS0Sensitivity   | AI                  | Controls the Sensitivity and Debounce values of CS0                                  | Ground     |
| 11  | Delay            | AI                  | Controls the LED ON time and serial debug data out                                   | Ground     |
| 12  | V <sub>SS</sub>  | P                   | Ground   | N/A        |
| 13  | Toggle/FSS       | AI                  | Controls the enabling/disabling of Toggle ON/OFF and FSS                             | Ground     |
| 14  | ARST/EMC         | AI                  | Controls the Button Auto Reset period, enabling / disabling Noise Immunity technique | Ground     |
| 15  | ScanRate/Sleep   | DI                  | Controls the button scan rate  | Ground     |
| 16  | GPO5             | DO                  | GPO activated by CS5   | Leave open |
| 17  | XRES             | DI                  | Device reset, active high input, with internal pull down                             | Leave open |
| 18  | GPO6             | DO                  | GPO activated by CS6   | Leave open |
| 19  | GPO7             | DO                  | GPO activated by CS7   | Leave open |
| 20  | GPO8             | DO                  | GPO activated by CS8   | Leave open |
| 21  | GPO9             | DO                  | GPO activated by CS9   | Leave open |
| 22  | CS9              | AI                  | CapSense button input, controls GPO9   | Ground     |
| 23  | CS8              | AI                  | CapSense button input, controls GPO8   | Ground     |
| 24  | CS7              | AI                  | CapSense button input, controls GPO7   | Ground     |
| 25  | CS6              | AI                  | CapSense button input, controls GPO6   | Ground     |
| 26  | CS5              | AI                  | CapSense button input, controls GPO5   | Ground     |
| 27  | CS4              | AI                  | CapSense button input, controls GPO4   | Ground     |
| 28  | V <sub>DD</sub>  | P                   | Power  | N/A        |
| 29  | CS3              | AI                  | CapSense button input, controls GPO3   | Ground     |
| 30  | CS2              | AI                  | CapSense button input, controls GPO2   | Ground     |
| 31  | C <sub>MOD</sub> | AI                  | External modulator capacitor, recommended value 2.2 nF (±10%)                        | N/A        |
| 32  | V <sub>SS</sub>  | P                   | Ground   | N/A        |

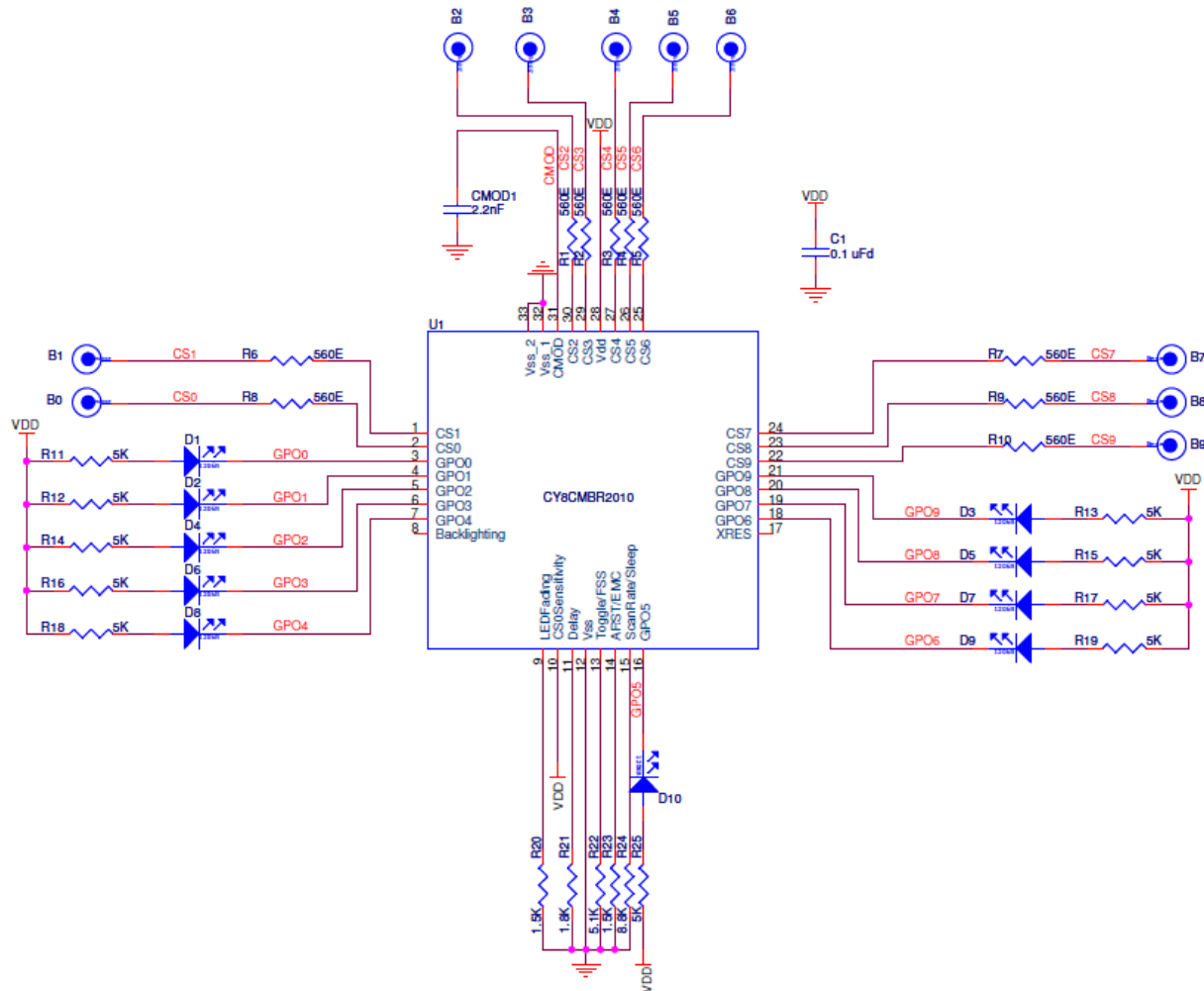

**Note**

2. AI – Analog Input; DI – Digital Input; DO – Digital Output; P – Power

## Typical Circuits

Schematic #1: Ten Buttons with Ten GPOs

Figure 1. CY8CMBR2010 Schematic 1



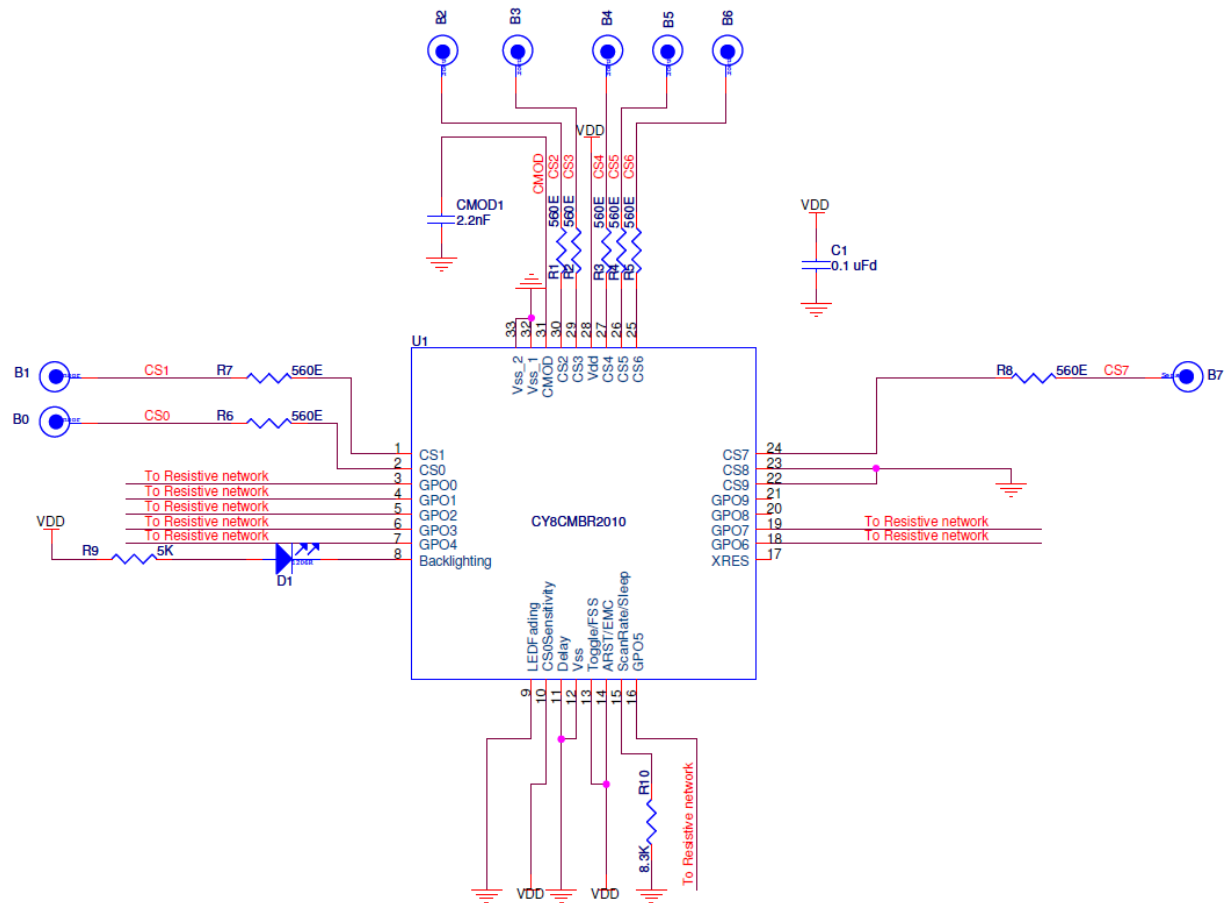
In Figure 1, the device is configured in the following manner:

- CS0-CS9 pins: 560 Ω to CapSense buttons
  - Ten CapSense buttons (CS0–CS9)
- GPO0-GPO9 pins: LED and 5 kΩ to V<sub>DD</sub>
  - CapSense buttons driving 10 LEDs (GPO0–GPO9)
- C<sub>MOD</sub> pin: 2.2 nF to Ground
  - Modulator capacitor
- XRES pin: Floating
  - For external reset
- Toggle/FSS pin: 5.1 kΩ to Ground
  - Toggle ON/OFF disabled
  - Flanking sensor suppression (FSS) enabled
- ARST/EMC pin: 1.5 kΩ to Ground
  - Button Auto Reset enabled
  - Noise Immunity level “Normal”

- LEDFading pin: 1.5 kΩ to Ground
  - Analog Voltage Support disabled
  - Power-on LED effects sequence 1
- Backlighting pin: Floating
  - No LED Backlighting output, as Analog Voltage Support disabled
- Delay pin: 1.8 kΩ to Ground
  - LED ON Time of 1000 ms
  - Serial Debug Data out disabled
- CS0Sensitivity pin: V<sub>DD</sub>
  - CS0 Sensitivity “Low”
  - CS0 Debounce = 99
- ScanRate/Sleep pin: 8.8 kΩ to Ground
  - Power consumption optimization
  - User configured scan rate = 298 ms

## Schematic #2: Eight Buttons with Analog Voltage Output

**Figure 2. CY8CMBR2010 Schematic 2**



In Figure 2, the device is configured in the following manner:

- CS0 - CS7 pins: 560 Ω to CapSense buttons; CS8, CS9 pins: Ground
  - Eight CapSense buttons (CS0–CS7)
  - CS8, CS9 buttons not used in design
- GPO0-GPO9 pins: Connect to external resistive network
  - Eight GPOs (GPO0–GPO7) used for Analog Voltage Output
  - GPO8, GPO9 not used in design
- C<sub>MOD</sub> pin: 2.2 nF to Ground
  - Modulator capacitor
- XRES pin: Floating
  - For external reset
- Toggle/FSS pin: V<sub>DD</sub>
  - Toggle ON/OFF enabled
  - Flanking sensor suppression (FSS) enabled
- ARST/EMC pin: V<sub>DD</sub>
  - Button Auto Reset enabled
  - Noise Immunity level “High”

- LEDFading pin: Ground
  - Analog Voltage Support enabled
  - Power-on LED effects disabled
- Backlighting pin: LED and 5 kΩ to V<sub>DD</sub>
  - LED Backlighting output, as Analog Voltage Support enabled
- Delay pin: Ground
  - LED ON Time disabled
  - Serial Debug Data out disabled
- CS0Sensitivity pin: V<sub>DD</sub>
  - CS0 Sensitivity “Low”
  - CS0 Debounce = 99
- ScanRate/Sleep pin: 8.3 kΩ to Ground
  - Power consumption optimization
  - User configured scan rate = 210 ms

## Configuring the CY8CMBR2010

The CY8CMBR2010 device features are configured using external resistors.

The resistors on the hardware configurable pins are determined by the device upon power-on.

The [Appendix on page 29](#) gives the matrix of features enabled using different external resistor configurations.

To know more about the required settings for your design, refer to the [CY8CMBR2010 Design Guide](#).

## Device Features

### CapSense Buttons

- Supports up to ten CapSense buttons.
- Ground the CSx pin to disable CapSense button input.
- A 2.2 nF ( $\pm 10\%$ ) capacitor must be connected on the C<sub>MOD</sub> pin for proper CapSense operation.
- For proper CapSense operation, ensure C<sub>p</sub> of each button is less than 40 pF.

### SmartSense™ Auto-Tuning

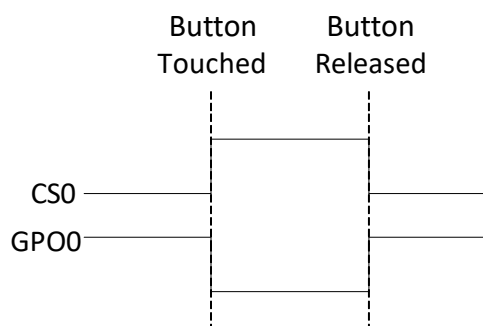
- Supports auto-tuning of CapSense parameters
- No manual tuning required; all parameters are automatically tuned by the device.
- Reduces the design cycle time.
  - No manual tuning.

- Ensures portability of the user interface design.
- Compensates Printed Circuit Board (PCB) variations, Device process variations, and PCB vendor changes.

### General-Purpose Outputs

- GPOx pin outputs are strong drive<sup>[3]</sup>
- The GPOx is controlled by the corresponding CSx
- Active low output – supports sinking configuration for LEDs (see [Figure 3](#))
- If CSx is disabled (grounded), then the corresponding GPOx must be left floating
- A 5-ms pulse is sent after 350 ms (if Noise Immunity level is “Normal”) / 1000 ms (if Noise Immunity level is “High”) after power-up on the GPOx if the CSx fails the System Diagnostics

**Figure 3. Example of GPO0 Driven by CS0**



**Table 2. Advanced Features Supported by CY8CMBR2010**

| Feature  | Benefit  |
|--|--|
| <a href="#">Toggle ON/OFF</a>  | Button retains state on touch (ON/OFF)   |
| <a href="#">Flanking Sensor Suppression (FSS)</a>                                      | Helps in distinguishing closely spaced buttons                                 |
| <a href="#">Noise Immunity</a>   | Improves device immunity to external noise (such as RF noise)                  |
| <a href="#">LED ON Time</a>  | Gives an LED effect on button release  |
| <a href="#">Button Auto Reset</a>  | Disables false output trigger, due to conducting object placed close to button |
| <a href="#">Power-on LED Effects</a>   | Provides visual effects to design at power-on                                  |
| <a href="#">Analog Voltage Support</a>   | External resistors can be used with GPOs to generate analog voltage output     |
| <a href="#">LED Backlighting</a>   | Common GPO available for LED drive if Analog Voltage Support enabled           |
| <a href="#">Sensitivity Control for CS0 Button and Debounce Control for CS0 Button</a> | Useful for special function buttons such as power button                       |
| <a href="#">System Diagnostics</a>   | Support for production testing and debugging                                   |
| <a href="#">Serial Debug Data</a>  | Support for production testing and validating design                           |
| <a href="#">Low Power Sleep Mode and Deep Sleep Mode</a>                               | Low power consumption  |

#### Note

3. When a pin is in strong drive mode, it is pulled up to V<sub>DD</sub> when the output is HIGH and pulled down to Ground when the output is LOW.

### Toggle ON/OFF

- Toggles the GPO state at each button touch (see [Figure 4](#)).
- Used for mechanical button replacement. For example, wall switch.

### Flanking Sensor Suppression (FSS)

- Helps in distinguishing closely spaced buttons.
- Also used in situations with buttons having opposite functions. For example, an interface with two buttons for brightness control (UP or DOWN).
- FSS action can be explained for following different scenarios:
  1. When only one button is touched, it is reported as ON. See [Figure 5](#).
  2. When more than one button is detected as ON and previously one of those buttons was touched, then the previously touched button is reported as ON. See [Figure 6](#).

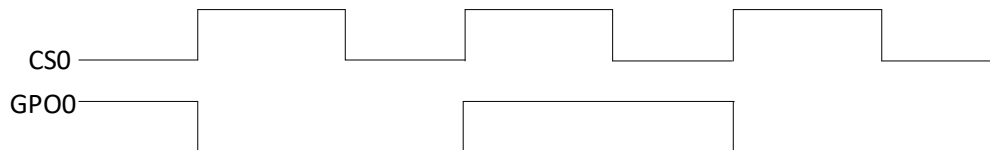
### Noise Immunity

- Improves the immunity of the device against external radiated and conducted noise.
- Reduces the radiated noise emission.
- Possible Noise Immunity levels are “Normal” and “High”.

### LED ON Time

- Provides better visual feedback when a button is released and improves the design’s aesthetic value.
- The GPOx is driven low for a specified interval after the corresponding CSx button is released (see [Figure 7](#)).
- When a button gets reset (refer to [Button Auto Reset on page 8](#)), LED ON Time is not applied on the corresponding GPO.
- Applicable to the GPO of the last button released.
- In [Figure 8 on page 8](#), GPO0 goes high prematurely (prior to LED ON Time expiration) because CS1 button is released. Therefore, the LED ON Time counter is reset. Now, GPO1 remains low for LED ON Time after releasing CS1.
- LED ON time can range from 0–2000 ms.
- LED ON time resolution is 20 ms.

**Figure 4. Example of Toggle ON/OFF Feature on GPO0**

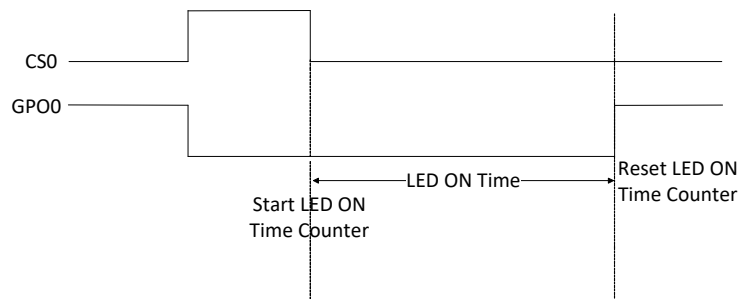
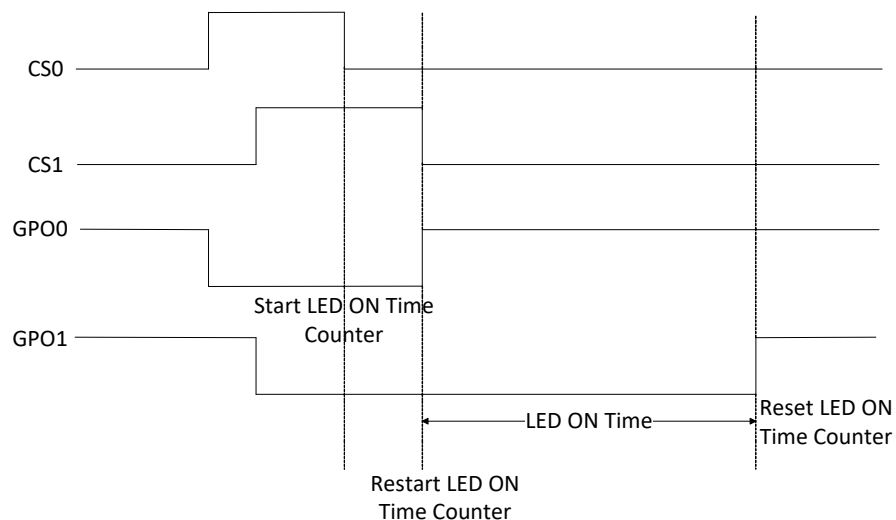


**Figure 5. FSS when only one button is touched**



**Figure 6. FSS when multiple buttons are touched with one button ON previously**

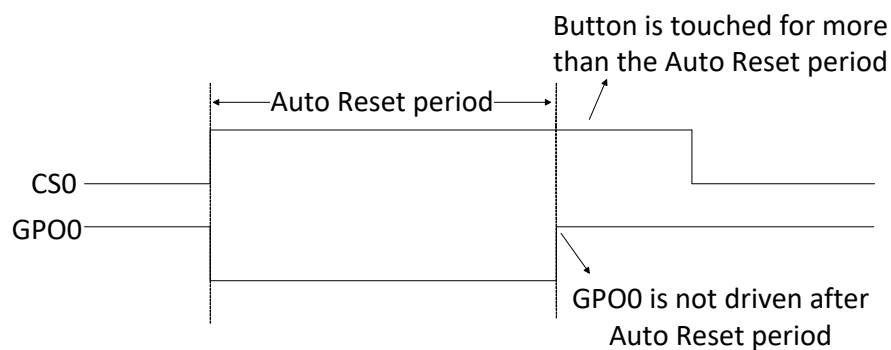


**Figure 7. Example LED ON timing diagram on GPO0**

**Figure 8. Example LED ON Timing Diagram on GPO0 and GPO1**


### Button Auto Reset

- Prevents button stuck, due to metal object placed close to button.
- Useful when GPO output to be kept on only for a specific time.

- If enabled, the GPOx is driven for a maximum of ARST time when CSx is continuously touched. See [Figure 9](#).
- Auto reset period is 20 s.

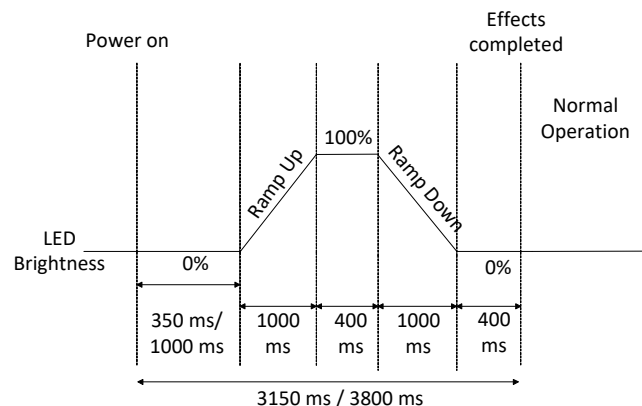
**Figure 9. Example of Button Auto Reset on GPO0**




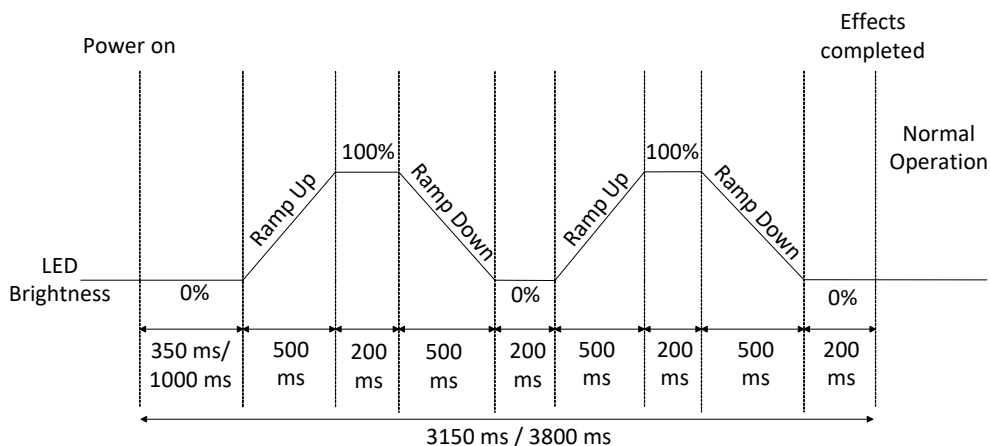
## Power-on LED Effects

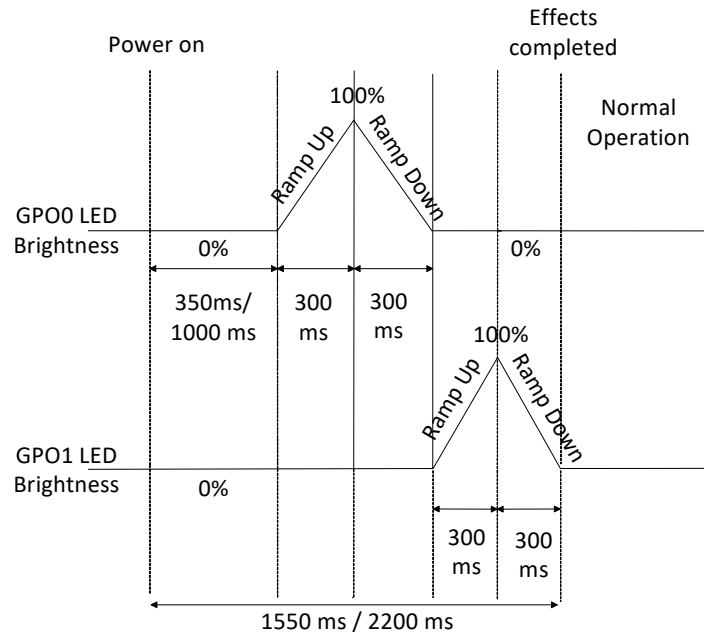
- Provides a visual effect at device power-up.
- After power on, all the LEDs show dimming and fading effects for an initial time.
- Seen on GPOx when CSx is enabled.
- All CapSense buttons are disabled during this time.
- If any CapSense button, CSx fails the Power-on Self Test then these effects are not seen on the corresponding GPOx.
- To know more about Power-on Self Test, refer [System Diagnostics](#).
- The following parameters are set for LED effects:
  - Low brightness – Minimum intensity of LED brightness.
  - Low brightness time – Time for which the LED stays in the Low Brightness state.
  - Ramp up time – Time taken by the LED to go from Low Brightness state to High Brightness state.
  - High brightness – Maximum intensity of LED brightness.
  - High brightness time – Time for which the LED stays in the High Brightness state.
  - Ramp down time – Time taken by the LED to go from High Brightness state to Low Brightness state.
  - Repeat Rate – The number of times the effect cycle is repeated.
- The effects are seen after the device initialization time from power-on. This time is less than 350 ms (if Noise Immunity level is “Normal”) and less than 1000 ms (if Noise Immunity level is “High”).
- The device responds to any button touch only after the effects are complete.
- There are three different predefined Power-on LED effects available.
- The different effects are as follows –
  - All the LEDs concurrently go to high brightness state and come back to low brightness state. See [Figure 10](#).
  - All the LEDs concurrently go to high brightness state and come back to low brightness state. This is repeated once (repeat rate = 2). See [Figure 11](#).
  - All the LEDs sequentially go to high brightness state and come back to low brightness state. See [Figure 12 on page 10](#).

**Figure 10. Power-on LED Effect Sequence 1**



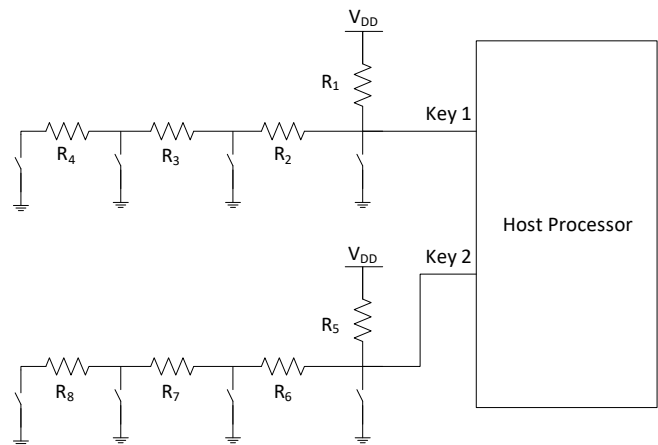
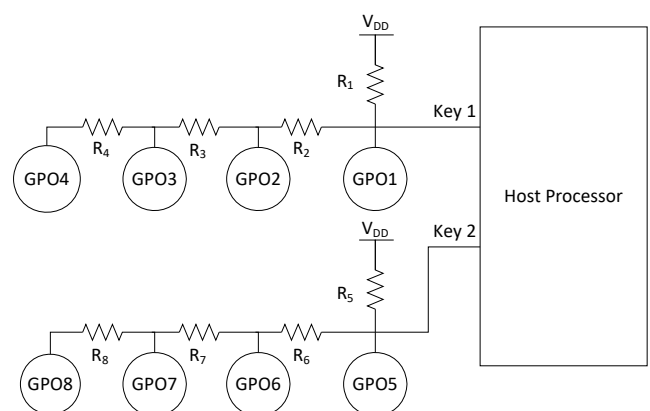
**Figure 11. Power-on LED Effect Sequence 2**



**Figure 12. Power-on LED Effect Sequence 3 with Two Button Design**


### Analog Voltage Support

- A general external resistive network with a host processor is shown in [Figure 13](#).
- Host can be configured to perform different functions based on the voltage level at input pins. This is controlled by switches.
- These switches can be controlled by CapSense buttons.
- If enabled, GPOs replace these switches in the network.
- GPOs are in Open Drain Low drive mode.
- GPOs cannot be used for the resistive network and LED drive simultaneously. Instead, the Backlighting pin acts as a GPO for LED drive, controlled by all the CSx buttons.
- If only one button needs to be ON for analog voltage support, FSS should be enabled.
- For CY8CMBR2010, a simple external resistive network is shown in [Figure 14](#).

**Figure 13. A General External Resistive Network**

**Figure 14. Analog Voltage Support for CY8CMBR2010**


## LED Backlighting

- Acts as a GPO for LED drive; controlled by all the CapSense buttons CSx.
- Can be used when Analog Voltage Support is enabled.
- Backlighting is a strong drive, active low output. It goes low if one or more CapSense button is touched.

## Sensitivity Control for CS0 Button

- Sensitivity of all buttons except CS0 is "High".
- CS0 can have "Low" sensitivity as well for special purpose, such as a power button.
- Use higher sensitivity setting when the overlay thickness is higher.

## Debounce Control for CS0 Button

- Avoids false triggering of button due to noise spike or any other glitches in the system.
- Specifies the minimum time for which CS0 has to be touched, for an output trigger.
- Useful for added functionalities. Example, linking system reset to touch time corresponding to CS0 Debounce.

## System Diagnostics

- A built-in Power-on Self Test (POST) mechanism performs some tests at power-on reset (POR), which can be useful in production testing.
- If any button fails these tests, a 5 ms pulse is sent out on the corresponding GPO within 350 ms (if Noise Immunity level is "Normal") / 1000 ms (if Noise Immunity level is "High") after POR.
- Following tests are performed on all the buttons –

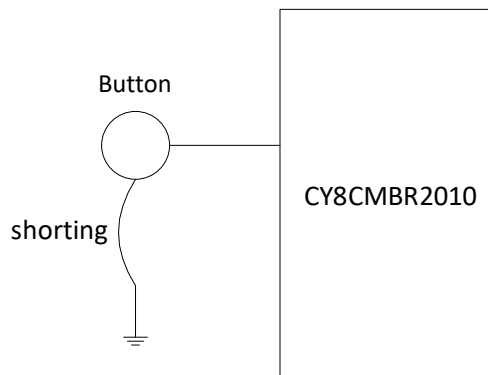
### Button Shorted to Ground

If any button is found to be shorted to ground, it is disabled. For an accurate detection of Button shorted to ground, the resistance between the CSx pin and ground should be less than the limits specified in [Table 3](#). See [Figure 15](#).

**Table 3. Maximum Resistance between CSx and GND for Proper System Diagnostics Operation**

| Power Supply ( $V_{DD}$ ) (V) | Max Resistance between CSx and GND ( $\Omega$ ) |
|-------------------------------|---|
| 5.5                           | 680   |
| 5                             | 760   |
| 1.8                           | 1700  |

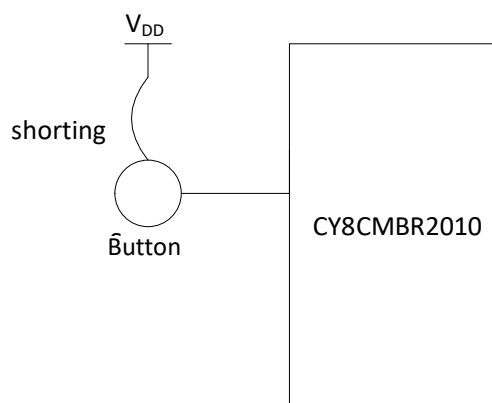
**Figure 15. Button Shorted to Ground**



### Button Shorted to $V_{DD}$

If any button is found to be shorted to  $V_{DD}$ , it is disabled. See [Figure 16](#).

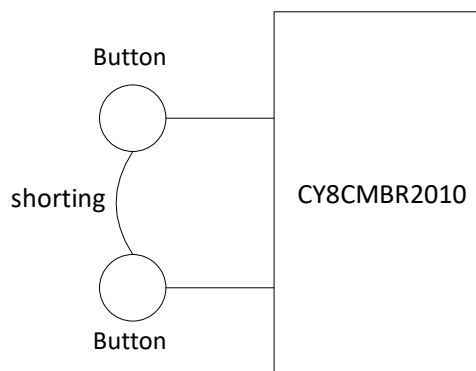
**Figure 16. Button Shorted to  $V_{DD}$**



### Button to Button Short

If two or more buttons are found to be shorted to each other, all of these buttons are disabled. See [Figure 17](#).

**Figure 17. Button to Button Short**



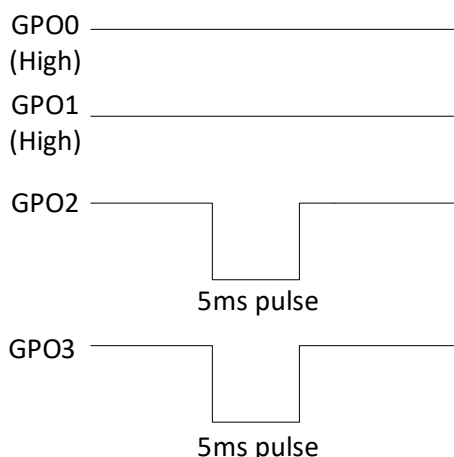
### Improper Value of $C_{MOD}$

- Recommended value of  $C_{MOD}$  is 2 nF to 2.4 nF.
- If the value of  $C_{MOD}$  is found to be less than 1 nF or greater than 4 nF, all the buttons are disabled.

### Button $C_P > 40$ pF

If the parasitic capacitance ( $C_P$ ) of any button is found to be more than 40 pF, that button is disabled.

**Figure 18. Example Showing CS0 and CS1 Passing the POST and CS2 and CS3 Failing**



In Figure 18, CS0 and CS1 buttons are enabled; CS2 and CS3 buttons are disabled because they failed the Power-on Self Test. A 5 ms pulse is observed on GPO2 and GPO3.

### Serial Debug Data

- Used to see CapSense data through the Delay pin.
- If enabled, debug data is transmitted on Delay pin using UART communication protocol.
- Serial data is sent out with ~115,200 baud rate.
- The Cypress MultiChart tool can be used to view the data as a graph.
- The following data is sent out by the device for all the buttons enabled –
  - Firmware revision
  - CapSense button status
  - GPO status
  - Raw Counts of all buttons
  - Baseline of all buttons
  - Difference Counts of all buttons
  - Parasitic capacitance of all buttons
  - SNR of all buttons
  - System Diagnostics data
  - Compensated IDAC value

For more information on Raw Count, Baseline, Difference count, Parasitic capacitance and SNR, refer [Getting Started with CapSense](#) section 2. For more information on MultiChart tool, refer [AN2397 CapSense Data Viewing Tools](#) Method 2.

- The MultiChart tool arranges the data in the format as shown in [Table 4](#).
- The serial debug data is sent by the device in the order as per [Table 5](#).

**Table 4. Serial Debug Data arranged in MultiChart**

| #  | Raw count array |             | Baseline Array |               | Signal Array          |                |
|----|-----------------|-------------|----------------|---------------|-----------------------|----------------|
|    | MSB             | LSB         | MSB            | LSB           | MSB                   | LSB            |
| 0  | 0x80            | FW Revision | 0x00           | CS_status_MSB | IDAC_Comp             | GPO_Status_MSB |
| 1  | CS0_Cp          | CS1_Cp      | 0x00           | CS_status_LSB | 0x00                  | GPO_Status_LSB |
| 2  | CS0_RawCount    |             | CS0_Baseline   |               | CS0_DiffCount         |                |
| 3  | CS1_RawCount    |             | CS1_Baseline   |               | CS1_DiffCount         |                |
| 4  | CS2_RawCount    |             | CS2_Baseline   |               | CS2_DiffCount         |                |
| 5  | CS3_RawCount    |             | CS3_Baseline   |               | CS3_DiffCount         |                |
| 6  | CS4_RawCount    |             | CS4_Baseline   |               | CS4_DiffCount         |                |
| 7  | CS5_RawCount    |             | CS5_Baseline   |               | CS5_DiffCount         |                |
| 8  | CS6_RawCount    |             | CS6_Baseline   |               | CS6_DiffCount         |                |
| 9  | CS7_RawCount    |             | CS7_Baseline   |               | CS7_DiffCount         |                |
| 10 | CS8_RawCount    |             | CS8_Baseline   |               | CS8_DiffCount         |                |
| 11 | CS9_RawCount    |             | CS9_Baseline   |               | CS9_DiffCount         |                |
| 12 | CS2_Cp          | CS3_Cp      | CS4_Cp         | CS5_Cp        | CS7_Cp                | CS8_Cp         |
| 13 | 0x00            | CS0_CS1_SNR | CS6_Cp         | CS4_CS5_SNR   | CS9_Cp                | CS8_CS9_SNR    |
| 14 | 0x00            | CS2_CS3_SNR | 0x00           | CS6_CS7_SNR   | 0x00                  | CMOD_Mask      |
| 15 | VDD_Short_Mask  |             | GND_Short_Mask |               | Pin_to_pin_short_Mask |                |
| 16 | 0x00            | 0x01        | 0x00           | 0x02          | Cp_High_Mask          |                |

**Table 5. Serial Debug Data Output sent by CY8CMBR2010**

| Byte | Data               | Notes  |
|------|--------------------|--|
| 0    | 0x0D               | Dummy data for multi chart                                     |
| 1    | 0x0A               |  |
| 2    | 0x80               |  |
| 3    | FW Revision        | Firmware Revision  |
| 4    | CS0_Cp             | CS0 parasitic capacitance (pF) in Hex                          |
| 5    | CS1_Cp             | CS1 parasitic capacitance (pF) in Hex                          |
| 6    | CS0_RawCount_MSB   | Unsigned 16-bit integer  |
| 7    | CS0_RawCount_LSB   |  |
| 8    | CS1_RawCount_MSB   | Unsigned 16-bit integer  |
| 9    | CS1_RawCount_LSB   |  |
| .    | .                  | .  |
| 24   | CS9_RawCount_MSB   | Unsigned 16-bit integer  |
| 25   | CS9_RawCount_LSB   |  |
| 26   | CS2_Cp             | CS2 parasitic capacitance (pF) in Hex                          |
| 27   | CS3_Cp             | CS3 parasitic capacitance (pF) in Hex                          |
| 28   | 0x00               | –  |
| 29   | CS0_CS1_SNR        | CS0 and CS1 SNR  |
| 30   | 0x00               | –  |
| 31   | CS2_CS3_SNR        | CS2 and CS3 SNR  |
| 32   | VDD_Short_Mask_MSB | System Diagnostics data for CS pins shorted to V <sub>DD</sub> |
| 33   | VDD_Short_Mask_LSB |  |
| 34   | 0x00               | –  |
| 35   | 0x01               |  |
| 36   | 0x00               | –  |
| 37   | CS_status_MSB      | Gives CS status for CS8–CS9                                    |
| 38   | 0x00               | –  |
| 39   | CS_status_LSB      | Gives CS status for CS0–CS7                                    |
| 40   | CS0_Baseline_MSB   | Unsigned 16-bit integer  |
| 41   | CS0_Baseline_LSB   |  |
| 42   | CS1_Baseline_MSB   | Unsigned 16-bit integer  |
| 43   | CS1_Baseline_LSB   |  |
| .    | .                  | .  |
| 58   | CS9_Baseline_MSB   | Unsigned 16-bit integer  |
| 59   | CS9_Baseline_LSB   |  |
| 60   | CS4_Cp             | CS4 parasitic capacitance (pF) in Hex                          |
| 61   | CS5_Cp             | CS5 parasitic capacitance (pF) in Hex                          |
| 62   | CS6_Cp             | CS6 parasitic capacitance (pF) in Hex                          |
| 63   | CS4_CS5_SNR        | CS4 and CS5 SNR  |
| 64   | 0x00               | –  |
| 65   | CS6_CS7_SNR        | CS6 and CS7 SNR  |

**Table 5. Serial Debug Data Output sent by CY8CMBR2010 (continued)**

| Byte | Data                        | Notes   |
|------|-----------------------------|---|
| 66   | GND_Short_Mask_MSB          | System Diagnostics data for CS pins shorted to GND        |
| 67   | GND_Short_Mask_LSB          |   |
| 68   | 0x00                        |   |
| 69   | 0x02                        | –   |
| 70   | IDAC_Comp                   | Compensated IDAC  |
| 71   | GPO_Status_Mask_MSB         | Gives GPO status for GPO8–GPO9                            |
| 72   | 0x00                        | –   |
| 73   | GPO_Status_Mask_LSB         | Gives GPO status for GPO0–GPO7                            |
| 74   | CS0_DiffCount_MSB           | Unsigned 16-bit integer                                   |
| 75   | CS0_DiffCount_LSB           |   |
| 76   | CS1_DiffCount_MSB           | Unsigned 16-bit integer                                   |
| 77   | CS1_DiffCount_LSB           |   |
| ·    | ·                           | ·   |
| ·    | ·                           | ·   |
| 92   | CS9_DiffCount_MSB           | Unsigned 16-bit integer                                   |
| 93   | CS9_DiffCount_LSB           |   |
| 94   | CS7_Cp                      | CS7 parasitic capacitance (pF) in Hex                     |
| 95   | CS8_Cp                      | CS8 parasitic capacitance (pF) in Hex                     |
| 96   | CS9_Cp                      | CS9 parasitic capacitance (pF) in Hex                     |
| 97   | CS8_CS9_SNR                 | CS8 and CS9 SNR   |
| 98   | 0x00                        | –   |
| 99   | CMOD_Mask                   | System Diagnostics data for C <sub>MOD</sub> out of range |
| 100  | Pin_to_Pin_shorted_Mask_MSB | System Diagnostics data for CS pin to pin short           |
| 101  | Pin_to_Pin_shorted_Mask_LSB |   |
| 102  | Cp_High_Mask_MSB            | System Diagnostics data for CS button Cp > 40 pF          |
| 103  | Cp_High_Mask_LSB            |   |
| 104  | 0x00                        | Dummy data for MultiChart                                 |
| 105  | 0xFF                        |   |
| 106  | 0xFF                        |   |

System Diagnostics data contains the POST results. This is as follows:

- **VDD\_Short\_Mask** – This contains the information about any button short to V<sub>DD</sub>. The MSB and LSB of this data contain the following.

**Table 6. VDD\_Short\_Mask**

| Name               | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| VDD_Short_Mask_LSB | CS7   | CS6   | CS5   | CS4   | CS3   | CS2   | CS1   | CS0   |
| VDD_Short_Mask_MSB |       |       |       |       |       |       | CS9   | CS8   |

For CS<sub>x</sub>, the corresponding bit is written as:

0 .....If the CS<sub>x</sub> is not shorted to V<sub>DD</sub>

1 .....If the CS<sub>x</sub> is shorted to V<sub>DD</sub>

- **GND\_Short\_Mask** – This contains the information about any button short to Ground. The MSB and LSB of this data contain the following.

**Table 7. GND\_Short\_Mask**

| Name               | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| GND_Short_Mask_LSB | CS7   | CS6   | CS5   | CS4   | CS3   | CS2   | CS1   | CS0   |
| GND_Short_Mask_MSB |       |       |       |       |       |       | CS9   | CS8   |

For CS<sub>x</sub>, the corresponding bit is written as:

- 0 ..... If the CS<sub>x</sub> is not shorted to ground  
 1 ..... If the CS<sub>x</sub> is shorted to ground

- **CMOD\_Mask** – This contains the information about the C<sub>MOD</sub> value within range. This byte is written as:

- 0 ..... If the C<sub>MOD</sub> value is within range (between 1 nF–4 nF)  
 1 ..... If the C<sub>MOD</sub> value > 4 nF  
 2 ..... If the C<sub>MOD</sub> value < 1 nF

- **Pin\_to\_Pin\_Short\_Mask** – This contains the information about any button to button short. The MSB and LSB of this data contain the following.

**Table 8. Pin\_to\_Pin\_Short\_Mask**

| Name                      | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Pin_to_Pin_Short_Mask_LSB | CS7   | CS6   | CS5   | CS4   | CS3   | CS2   | CS1   | CS0   |
| Pin_to_Pin_Short_Mask_MSB |       |       |       |       |       |       | CS9   | CS8   |

For CS<sub>x</sub>, the corresponding bit is written as:

- 0..... If the CS<sub>x</sub> pin is not shorted to any other CS<sub>y</sub> pin  
 1..... If the CS<sub>x</sub> pin is shorted to another CS<sub>y</sub> pin

- **Cp\_High\_Mask** – This contains the information about the CS<sub>x</sub> button C<sub>p</sub> value within range. The MSB and LSB of this data contain the following

**Table 9. Cp\_High\_Mask**

| Name             | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Cp_High_Mask_LSB | CS7   | CS6   | CS5   | CS4   | CS3   | CS2   | CS1   | CS0   |
| Cp_High_Mask_MSB |       |       |       |       |       |       | CS9   | CS8   |

For CS<sub>x</sub>, the corresponding bit is written as:

- 0..... If the CS<sub>x</sub> C<sub>p</sub> value < 40 pF  
 1..... If the CS<sub>x</sub> C<sub>p</sub> value > 40 pF

## Power Consumption and Operating Modes

The CY8CMBR2010 is designed to meet the low power requirements of battery powered applications. To design for the lowest operating current –

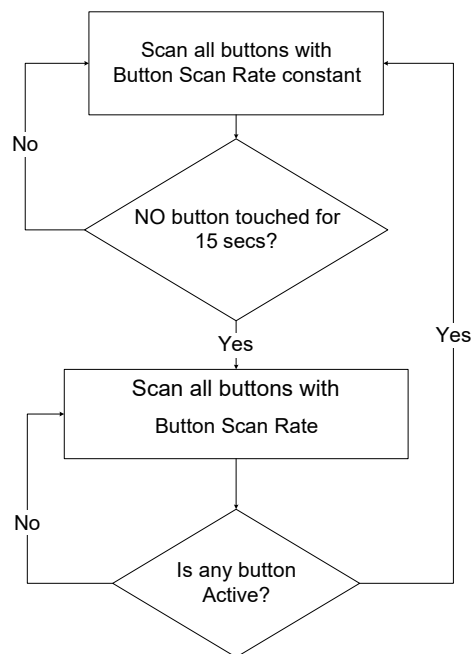
- Ground all unused CapSense inputs
- Minimize Cp using the design guidelines in [Getting Started with CapSense](#), section 3.7.1
- Lower the supply voltage (valid range: 1.71 V to 5.5 V)
- Reduce sensitivity of CS0 button
- Configure design to be power consumption optimized
- Use “High” Noise Immunity level only if required
- Use a higher Button Scan Rate or Deep Sleep operating mode

To know more about the steps to reduce power consumption, refer to the [CY8CMBR2010 Design Guide](#) section 5.

### Low Power Sleep Mode

The following flow chart describes the low power sleep mode operation.

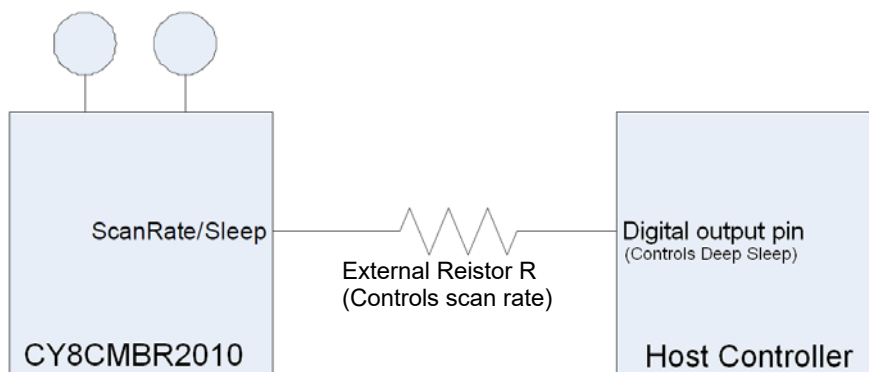
**Figure 19. Low Power Sleep Mode Operation**



- The Button Scan Rate is equal to the sum of the time the device scans and sleeps.
- An external resistor defines Button Scan Rate offset.
- The offset is added to a constant to get the Button Scan Rate.
- To know about the Button Scan Rate offset and the Button Scan Rate constant, refer to [Table 23 on page 30](#) and [Table 24 on page 31](#) in [Appendix](#).
- The range of scan rate is 25 to 556 ms.

### Deep Sleep Mode

**Figure 20. ScanRate/Sleep pin Connection to Enable Deep Sleep Mode**





- To enable the deep sleep mode, the ScanRate/Sleep pin should be connected to host controller as shown in [Figure 20 on page 16](#).
- Host controller should pull the pin to V<sub>DD</sub> for the device to go into deep sleep.
- In deep sleep mode, all blocks are turned off and the device power consumption is approximately 0.1 μA.
- There is no CapSense scanning in deep sleep mode.
- ScanRate/Sleep pin should be pulled low for the device to wake up from deep sleep.
- When device comes out of deep sleep mode, the CapSense system is reinitialized. Typical time for reinitialization is 20 ms (if Noise Immunity level is “Normal”) or 50 ms (if Noise Immunity level is “High”). Any button touch within this time is not reported.
- At power on, the ScanRate/Sleep pin should be pulled low.
- If the ScanRate/Sleep pin is pulled high at power on, then the device goes to Deep Sleep after the POST and Power-on LED effects are completed.

## Response Time

Response time is the minimum amount of time the button should be touched for the device to detect as valid button touch.

It is given by following equation

$$RT_{FBT} = \text{Button Scan Rate} + \left[ \text{Button Scan Rate constant} \times \left\{ \text{Round}_{\text{down}} \left( \frac{(\text{Debounce} - 1)}{3} \right) + 1 \right\} \right]$$

$$RT_{CBT} = \text{Button Scan Rate constant} + \left[ \text{Button Scan Rate constant} \times \left\{ \text{Round}_{\text{down}} ((\text{Debounce} - 1)/3) + 1 \right\} \right]$$

Where

RT<sub>FBT</sub> is Response time for First button touch

RT<sub>CBT</sub> is Response time for consecutive button touch after first button touch

Debounce for CS1–CS9 = 3

Debounce for CS0 can be one of 3 / 24 / 48 / 99

Round<sub>down</sub> is the greatest integer less than or equal to ((Debounce – 1)/3)

For example, consider an eight button design with the Delay pin connected to ground through a 3.2 kΩ resistor. This results in a Response Time optimized design with a User defined Button Scan rate of 556 ms (as per [Table 23 on page 30](#) and [Table 24 on page 31](#)).

Assuming that CS0 is not used in the design, the Debounce value for each button (CS1–CS8) is 3. The Button Scan Rate constant for such a design is 50 ms (as per [Table 24 on page 31](#)).

The response time for such a design is given as –

$$RT_{FBT} = 556 + [50 \times \{ \text{Round}_{\text{down}} ((3 - 1)/3) + 1 \}] = 606 \text{ ms}$$

$$RT_{CBT} = 50 + [50 \times \{ \text{Round}_{\text{down}} ((3 - 1)/3) + 1 \}] = 100 \text{ ms}$$

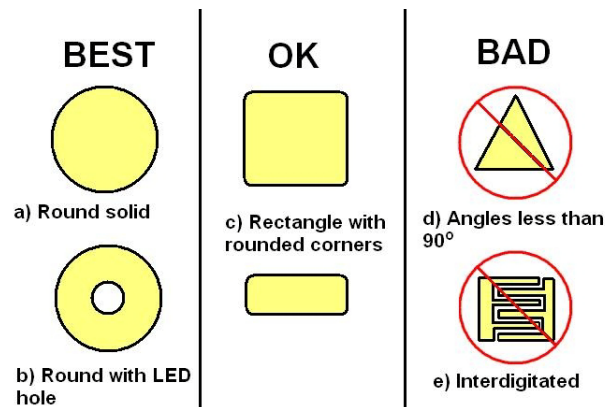
## Layout Guidelines and Best Practices

**Table 10. Layout Guidelines and Best Practices**

| Sl. No. | Category   | Min                              | Max     | Recommendations/Remarks  |
|---------|--|----------------------------------|---------|--|
| 1       | Button shape   | –                                | –       | Solid round pattern, round with LED hole, rectangle with round corners   |
| 2       | Button size  | 5 mm                             | 15 mm   | Refer <a href="#">Design toolbox</a> .   |
| 3       | Button-button spacing                                    | Equal to Button Ground Clearance | –       | 8 mm (Y dimension in <a href="#">Figure 22 on page 19</a> )  |
| 4       | Button ground clearance                                  | 0.5 mm                           | 2 mm    | Refer <a href="#">Design toolbox</a> (X dimension in <a href="#">Figure 22 on page 19</a> ).   |
| 5       | Ground flood – top layer                                 | –                                | –       | Hatched ground 7 mil trace and 45 mil grid (15% filling).  |
| 6       | Ground flood – bottom layer                              | –                                | –       | Hatched ground 7 mil trace and 70 mil grid (10% filling).  |
| 7       | Trace length from button pad to CapSense controller pins | –                                | 450 mm  | Refer <a href="#">Design toolbox</a> .   |
| 8       | Trace width  | 0.17 mm                          | 0.20 mm | 0.17 mm (7 mil)  |
| 9       | Trace routing  | –                                | –       | Traces should be routed on the non button side. If any non CapSense trace crosses CapSense trace, ensure that intersection is orthogonal.  |
| 10      | Via position for the buttons                             | –                                | –       | Via should be placed near the edge of the button pad to reduce trace length thereby increasing sensitivity.  |
| 11      | Via hole size for button traces                          | –                                | –       | 10 mil   |
| 12      | No. of via on button trace                               | 1                                | 2       | 1  |
| 13      | Distance of CapSense series resistor from button pin     | –                                | 10 mm   | Place CapSense series resistors close to the device for noise suppression. CapSense resistors have highest priority; place them first.   |
| 14      | Distance between any CapSense trace to ground Flood      | 10 mil                           | 20 mil  | 20 mil   |
| 15      | Device placement   | –                                | –       | Mount the Device on the layer opposite to button. The CapSense trace length between the Device and buttons should be minimum (see trace length above)  |
| 16      | Placement of components in two layer PCB                 | –                                | –       | Top Layer – buttons<br>Bottom layer – device, other components and traces.   |
| 17      | Placement of components in four layer PCB                | –                                | –       | Top Layer – buttons<br>Second Layer – CapSense traces and $V_{DD}$ (avoid $V_{DD}$ traces below the buttons)<br>Third Layer – hatched ground<br>Bottom layer – CapSense controller, other components and non CapSense traces |
| 18      | Overlay thickness  | 0 mm                             | 5 mm    | Refer <a href="#">Design toolbox</a> .   |
| 19      | Overlay material   | –                                | –       | Should be non-conductive material. Glass, ABS Plastic, Formica, wood and so on. There should be no air gap between PCB and overlay. Use adhesive to stick the PCB and overlay.   |
| 20      | Overlay adhesives  | –                                | –       | Adhesive should be non conductive and dielectrically homogenous. 467MP and 468MP adhesives made by 3M are recommended.   |
| 21      | LED back lighting  | –                                | –       | Cut a hole in the button pad and use rear mountable LEDs. Refer to the PCB layout below.   |
| 22      | Board thickness  | –                                | –       | Standard board thickness for CapSense FR4 based designs is 1.6 mm.   |

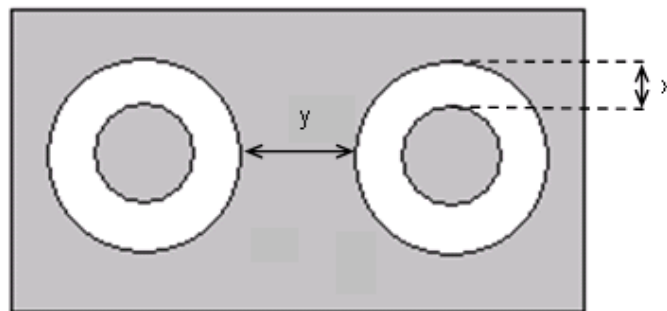
## CapSense Button shapes

Figure 21. CapSense button shapes



## Button Layout Design

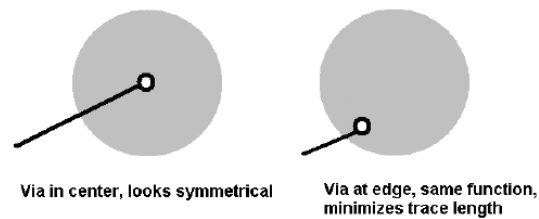
Figure 22. Button Layout Design



x: Button to ground clearance (Refer to [Layout Guidelines and Best Practices on page 18](#)).  
 y: Button to button clearance (Refer to [Layout Guidelines and Best Practices on page 18](#)).

## Recommended via-hole Placement

Figure 23. Recommended via-hole Placement



**Example PCB Layout Design with Ten CapSense Buttons and Ten GPOs**

**Figure 24. Top Layer**

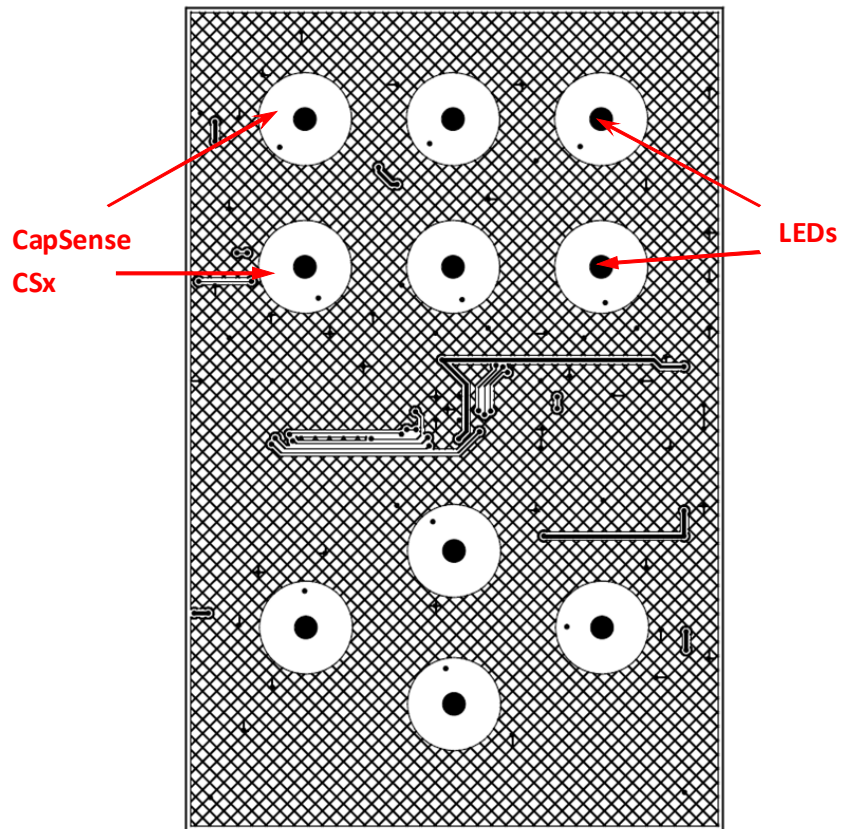
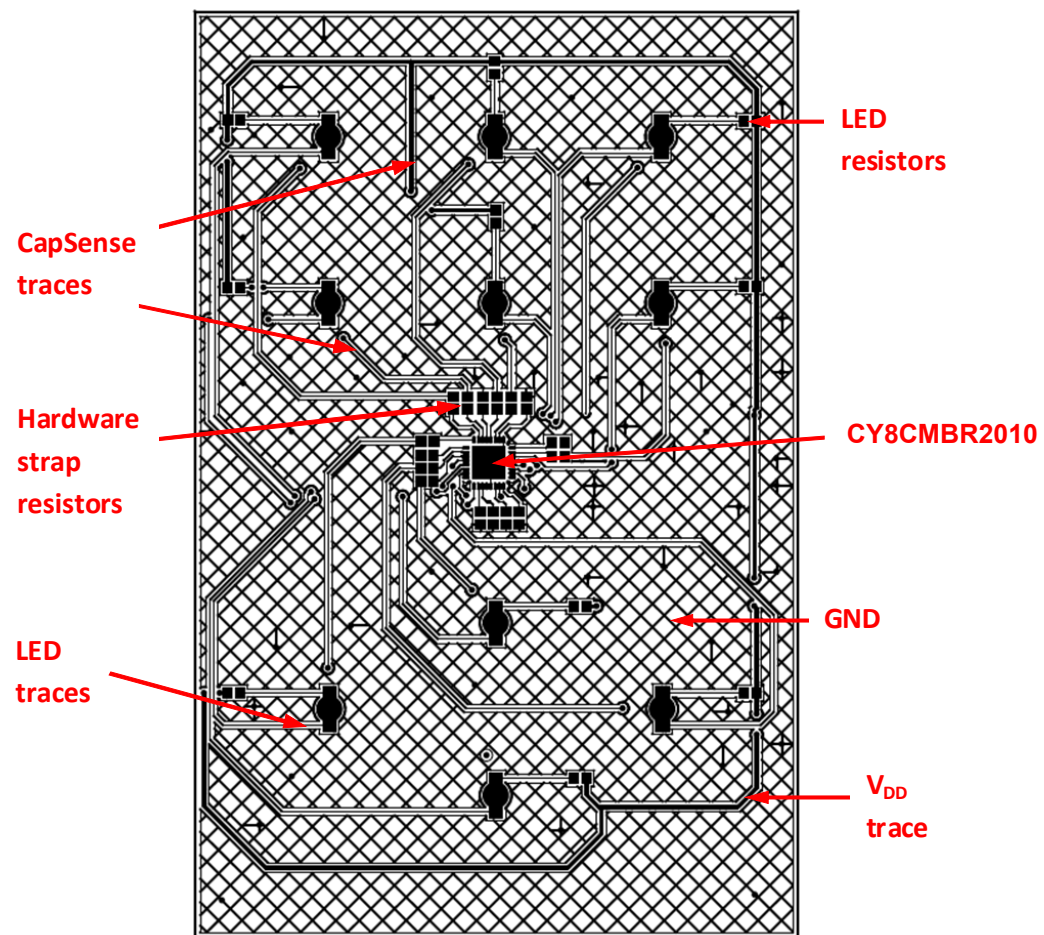


Figure 25. Bottom Layer



## Electrical Specifications

This section presents the DC and AC electrical specifications of the CY8CMBR2010 device.

### Absolute Maximum Ratings

Exceeding maximum ratings may shorten the useful life of the device.

**Table 11. Absolute Maximum Ratings**

| Parameter        | Description   | Min                   | Typ | Max                   | Unit | Conditions   |
|------------------|---|-----------------------|-----|-----------------------|------|--|
| T <sub>STG</sub> | Storage temperature                                   | –55                   | +25 | +125                  | °C   | Higher storage temperatures reduce data retention time. Recommended storage temperature is +25 °C ± 25 °C. Extended duration storage at temperatures above 85 °C degrades reliability. |
| V <sub>DD</sub>  | Supply voltage relative to V <sub>SS</sub>            | –0.5                  | –   | +6.0                  | V    |  |
| V <sub>IO</sub>  | DC voltage on CapSense inputs and digital output pins | V <sub>SS</sub> – 0.5 | –   | V <sub>DD</sub> + 0.5 | V    |  |
| I <sub>MIG</sub> | Maximum current into any GPO pin                      | –25                   | –   | +50                   | mA   |  |
| ESD              | Electro static discharge voltage                      | 2000                  | –   | –                     | V    | Human body model ESD   |
| LU               | Latch up current                                      | –                     | –   | 200                   | mA   | In accordance with JESD78 standard   |

### Operating Temperature

**Table 12. Operating Temperature**

| Parameter      | Description                 | Min | Typ | Max  | Unit | Notes  |
|----------------|-----------------------------|-----|-----|------|------|--|
| T <sub>A</sub> | Ambient temperature         | –40 | –   | +85  | °C   |  |
| T <sub>C</sub> | Commercial temperature      | 0   | –   | +70  | °C   |  |
| T <sub>J</sub> | Operational Die Temperature | –40 | –   | +100 | °C   | The temperature rise from ambient to junction is package specific. Refer to <a href="#">Table 20 on page 27</a> . The user must limit the power consumption to comply with this requirement. |

## DC Electrical Characteristics

### DC Chip Level Specifications

The following table lists guaranteed maximum and minimum specifications for the entire voltage and temperature ranges.

**Table 13. DC Chip-Level Specifications**

| Parameter            | Description             | Min  | Typ    | Max  | Unit          | Notes  |
|----------------------|-------------------------|------|--------|------|---------------|--|
| $V_{DD}^{[4, 5, 6]}$ | Supply voltage          | 1.71 | —      | 5.5  | V             |  |
| $I_{DD}$             | Supply current          | —    | 3.4    | 4.0  | mA            | $V_{DD} = 3.0\text{ V}$ , $T_A = 25\text{ }^{\circ}\text{C}$   |
| $I_{DA}$             | Active current          | —    | 3.4    | 4.0  | mA            | $V_{DD} = 3.0\text{ V}$ , $T_A = 25\text{ }^{\circ}\text{C}$ , continuous button scan  |
| $I_{DL}$             | Low power sleep current | —    | 1.07   | 1.50 | $\mu\text{A}$ | $V_{DD} = 3.0\text{ V}$ , $T_A = 25\text{ }^{\circ}\text{C}$   |
| $I_{DS}$             | Deep sleep current      | —    | 0.1    | 1.05 | $\mu\text{A}$ | $V_{DD} = 3.0\text{ V}$ , $T_A = 25\text{ }^{\circ}\text{C}$   |
| $I_{AV1}$            | Average current         | —    | 85.90  | —    | $\mu\text{A}$ | 4-buttons used, 3% touch time, $10\text{ pF} < C_P$ of all buttons $< 20\text{ pF}$ , Button Scan Rate = 556 ms, with power consumption optimized, Noise Immunity level "Normal", CS0 sensitivity "High" |
| $I_{AV2}$            | Average current         | —    | 131.50 | —    | $\mu\text{A}$ | 8-buttons used, 5% touch time, $10\text{ pF} < C_P$ of all buttons $< 20\text{ pF}$ , button scan rate = 556 ms, with response time optimized, Noise Immunity level "Normal", CS0 sensitivity "High"     |
| $I_{AV3}$            | Average current         | —    | 168.10 | —    | $\mu\text{A}$ | 10-buttons used, 5% touch time, $10\text{ pF} < C_P$ of all buttons $< 20\text{ pF}$ , button scan rate = 419 ms, with response time optimized, Noise Immunity level "Normal", CS0 sensitivity "High"    |

### Notes

- When  $V_{DD}$  remains in the range from 1.75 V to 1.9 V for more than 50  $\mu\text{s}$ , the slew rate when moving from the 1.75 V to 1.9 V range to greater than 2 V must be slower than 1 V/500  $\mu\text{s}$ . This helps to avoid triggering POR. The only other restriction on slew rates for any other voltage range or transition is the SRPOWER\_UP parameter.
- After power-down, ensure that  $V_{DD}$  falls below 100 mV before powering back up.
- For proper CapSense block functionality, if the drop in  $V_{DD}$  exceeds 5% of the base  $V_{DD}$ , the rate at which  $V_{DD}$  drops should not exceed 200 mV/s. Base  $V_{DD}$  can be between 1.8 V and 5.5 V.



### DC General-Purpose I/O Specifications

These tables list guaranteed maximum and minimum specifications for the voltage and temperature ranges: 3.0 V to 5.5 V and  $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ , 2.4 V to 3.0 V and  $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ , and 1.71 V to 2.4 V and  $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ , respectively. Typical parameters apply to 5 V and 3.3 V at  $25^{\circ}\text{C}$  and are for design guidance only.

**Table 14. 3.0 V to 5.5 V DC General-Purpose I/O Specifications**

| Parameter | Description  | Min             | Typ | Max  | Unit | Notes  |
|-----------|--|-----------------|-----|------|------|--|
| $V_{OH1}$ | High output voltage on GPO0–GPO9 (except GPO5)           | $V_{DD} - 0.20$ | –   | –    | V    | $I_{OH} \leq 10\ \mu\text{A}$ , maximum of 10 mA source current in all I/Os  |
| $V_{OH2}$ | High output voltage on GPO0–GPO9 (except GPO5)           | $V_{DD} - 0.90$ | –   | –    | V    | $I_{OH} = 1\ \text{mA}$ , maximum of 20 mA source current in all I/Os  |
| $V_{OH3}$ | High output voltage on GPO5, Backlighting, Delay pins    | $V_{DD} - 0.20$ | –   | –    | V    | $I_{OH} < 10\ \mu\text{A}$ , maximum of 10 mA source current in all I/Os   |
| $V_{OH4}$ | High output voltage on GPO5, Backlighting, Delay pins    | $V_{DD} - 0.90$ | –   | –    | V    | $I_{OH} = 5\ \text{mA}$ , maximum of 20 mA source current in all I/Os  |
| $V_{OL}$  | Low output voltage on all GPOs, Backlighting, Delay pins | –               | –   | 0.75 | V    | $I_{OL} = 25\ \text{mA}$ , $V_{DD} > 3.3\ \text{V}$ , maximum of 60 mA sink current on GPO0, GPO1, GPO2, GPO3, GPO4, Backlighting, Delay pins and 60 mA sink current on GPO5, GPO6, GPO7, GPO8, GPO9 pins. |
| $V_{IL}$  | Input low voltage  | –               | –   | 0.80 | V    |  |
| $V_{IH}$  | Input high voltage                                       | 2.00            | –   | –    | V    |  |

**Table 15. 2.4 V to 3.0 V DC General-Purpose I/O Specifications**

| Parameter | Description  | Min             | Typ | Max  | Unit | Notes  |
|-----------|--|-----------------|-----|------|------|--|
| $V_{OH1}$ | High output voltage on GPO0–GPO9 (except GPO5)           | $V_{DD} - 0.20$ | –   | –    | V    | $I_{OH} < 10\ \mu\text{A}$ , maximum of 10 mA source current in all I/Os   |
| $V_{OH2}$ | High output voltage on GPO0–GPO9 (except GPO 5)          | $V_{DD} - 0.40$ | –   | –    | V    | $I_{OH} = 0.2\ \text{mA}$ , maximum of 10 mA source current in all I/Os  |
| $V_{OH3}$ | High output voltage on GPO5, Backlighting, Delay pins    | $V_{DD} - 0.20$ | –   | –    | V    | $I_{OH} < 10\ \mu\text{A}$ , maximum of 10 mA source current in all I/Os   |
| $V_{OH4}$ | High output voltage on GPO5, Backlighting, Delay pins    | $V_{DD} - 0.50$ | –   | –    | V    | $I_{OH} = 2\ \text{mA}$ , maximum of 10 mA source current in all I/Os  |
| $V_{OL}$  | Low output voltage on all GPOs, Backlighting, Delay pins | –               | –   | 0.75 | –    | $I_{OL} = 5\ \text{mA}$ , maximum of 30 mA sink current on GPO0, GPO1, GPO2, GPO3, GPO4, Backlighting, Delay pins and 30 mA sink current on GPO5, GPO6, GPO7, GPO8, GPO9 pins. |
| $V_{IL}$  | Input low voltage  | –               | –   | 0.72 | V    |  |
| $V_{IH}$  | Input high voltage                                       | 1.40            | –   | –    | V    |  |



**Table 16. 1.71 V to 2.4 V DC General-Purpose I/O Specifications**

| Parameter        | Description  | Min                    | Typ | Max                   | Unit | Notes  |
|------------------|--|------------------------|-----|-----------------------|------|--|
| V <sub>OH1</sub> | High output voltage on GPO0–GPO9 (except GPO5)           | V <sub>DD</sub> – 0.20 | –   | –                     | V    | I <sub>OH</sub> = 10 µA, maximum of 10 mA source current in all I/Os   |
| V <sub>OH2</sub> | High output voltage on GPO0–GPO9 (except GPO5)           | V <sub>DD</sub> – 0.50 | –   | –                     | V    | I <sub>OH</sub> = 0.5 mA, maximum of 10 mA source current in all I/Os  |
| V <sub>OH3</sub> | High output voltage on GPO5, Backlighting, Delay pins    | V <sub>DD</sub> – 0.20 | –   | –                     | V    | I <sub>OH</sub> = 100 µA, maximum of 10 mA source current in all I/Os  |
| V <sub>OH4</sub> | High output voltage on GPO5, Backlighting, Delay pins    | V <sub>DD</sub> – 0.50 | –   | –                     | V    | I <sub>OH</sub> = 2 mA, maximum of 10 mA source current in all I/Os  |
| V <sub>OL</sub>  | Low output voltage on all GPOs, Backlighting, Delay pins | –                      | –   | 0.4                   | –    | I <sub>OL</sub> = 5 mA, maximum of 20 mA sink current on GPO5, GPO6, GPO7, GPO8, GPO9 pins and 30 mA sink current on GPO0, GPO1, GPO2, GPO3, GPO4, Backlighting, Delay pins. |
| V <sub>IL</sub>  | Input low voltage  | –                      | –   | 0.3 × V <sub>DD</sub> | V    |  |
| V <sub>IH</sub>  | Input high voltage                                       | 0.65 × V <sub>DD</sub> | –   | –                     | V    |  |

## AC Electrical Specifications

### AC Chip-Level Specifications

The following table lists guaranteed maximum and minimum specifications for the entire voltage and temperature ranges.

**Table 17. AC Chip – Level Specifications**

| Parameter              | Description                               | Min | Max | Unit | Notes   |
|------------------------|---|-----|-----|------|---|
| SR <sub>POWER_UP</sub> | Power supply slew rate                    | –   | 250 | V/ms | V <sub>DD</sub> slew rate during power-up.                    |
| T <sub>XRST</sub>      | External reset pulse width at power-up    | 1   | –   | ms   | Applicable after device power supply is active                |
| T <sub>XRST2</sub>     | External reset pulse width after power-up | 10  | –   | µs   | Applicable after device V <sub>DD</sub> has reached max value |

### AC General-Purpose I/O Specifications

The following table lists guaranteed maximum and minimum specifications for the entire voltage and temperature ranges.

**Table 18. AC General-Purpose I/O Specifications**

| Parameter   | Description   | Min | Typ | Max | Unit | Notes                                  |
|-------------|---|-----|-----|-----|------|--|
| $T_{Rise1}$ | Rise time, strong mode on GPO0–GPO9 (except GPO5), $C_{load} = 50$ pF                       | 15  | –   | 80  | ns   | $V_{DD} = 3.0$ to $3.6$ V, 10% to 90%  |
| $T_{Rise2}$ | Rise time, strong mode low supply on GPO5, Backlighting, Delay pins, $C_{load} = 50$ pF     | 10  | –   | 50  | ns   | $V_{DD} = 3.0$ to $3.6$ V, 10% to 90%  |
| $T_{Rise3}$ | Rise time on GPO0–GPO9 (except GPO5), $C_{load} = 50$ pF                                    | 15  | –   | 80  | ns   | $V_{DD} = 1.71$ to $3.0$ V, 10% to 90% |
| $T_{Rise2}$ | Rise time, strong mode low supply on GPO5, Backlighting, Delay pins, $C_{load} = 50$ pF     | 10  | –   | 80  | ns   | $V_{DD} = 1.71$ to $3.0$ V, 10% to 90% |
| $T_{Fall1}$ | Fall time, strong mode on all GPOs, Backlighting, Delay pins, $C_{load} = 50$ pF            | 10  | –   | 50  | ns   | $V_{DD} = 3.0$ to $3.6$ V, 90% to 10%  |
| $T_{Fall2}$ | Fall time, strong mode low supply on all GPOs, Backlighting, Delay pins, $C_{load} = 50$ pF | 10  | –   | 70  | ns   | $V_{DD} = 1.71$ to $3.0$ V, 90% to 10% |

### CapSense Specifications

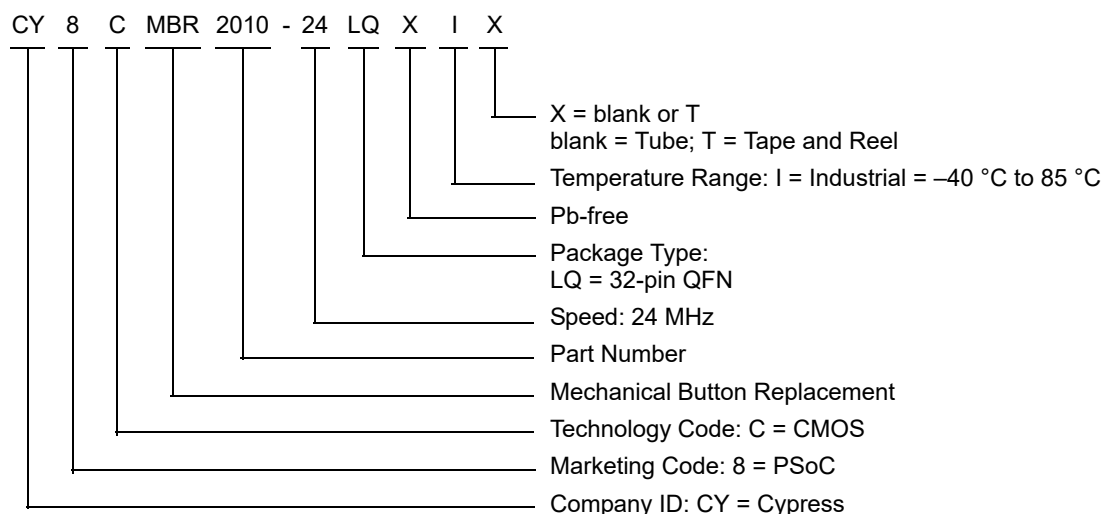
**Table 19. CapSense Specifications**

| Parameter | Description                                | Min  | Typ | Max                               | Unit     | Notes  |
|-----------|--|------|-----|-----------------------------------|----------|--|
| $C_P$     | Parasitic capacitance                      | 5    | –   | $(C_P + C_F) < 40$ <sup>[7]</sup> | pF       | $C_P$ is the total capacitance seen by the pin when no finger is present. $C_P$ is sum of $C_{BUTTON}$ , $C_{TRACE}$ , and Capacitance of the vias and $C_{PIN}$ . |
| $C_F$     | Finger capacitance                         | 0.25 | –   | $(C_P + C_F) < 40$ <sup>[7]</sup> | pF       | $C_F$ is the capacitance added by the finger touch.  |
| $C_{PIN}$ | Capacitive load on pins as input           | 0.5  | 1.7 | 7                                 | pF       |  |
| $C_{MOD}$ | External modulator capacitor               | 2    | 2.2 | 2.4                               | nF       | Mandatory requirement  |
| $R_S$     | Series resistor between Pin and the button | –    | 560 | 616                               | $\Omega$ | Reduces the RF noise.  |

#### Note

7. The max value of parasitic capacitance is 40 pF when the temperature is above 0 °C, and 38 pF at –45 °C.

| Ordering Code       | Package Type                                | Operating Temperature | CapSense Inputs | GPO's | XRESPin |
|---------------------|---|-----------------------|-----------------|-------|---------|
| CY8CMBR2010-24LQXI  | 32-pin (5 × 5 × 0.6 mm) QFN                 | Industrial            | 10              | 10    | Yes     |
| CY8CMBR2010-24LQXIT | 32-pin (5 × 5 × 0.6 mm) QFN (tape and reel) | Industrial            | 10              | 10    | Yes     |

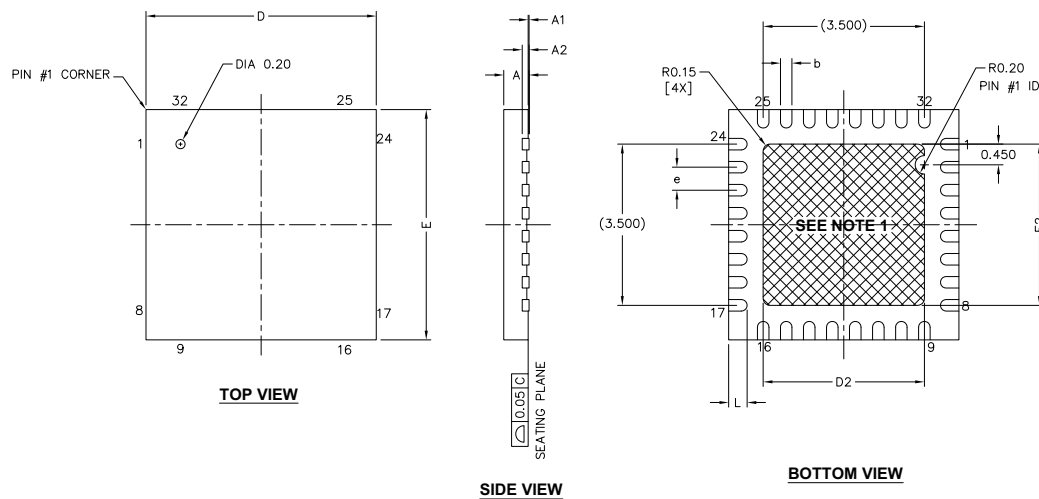


| Package                   | Typical $\theta_{JA}$ <sup>[8]</sup> |
|---------------------------|--------------------------------------|
| 32-pin QFN <sup>[9]</sup> | 20 °C/W                              |

| Package    | Minimum Peak Temperature<br>(T <sub>C</sub> ) | Maximum Time above<br>T <sub>C</sub> – 5 °C |
|------------|---|---|
| 32-pin QFN | 260 °C  | 30 seconds                                  |


## Package Diagram

**Figure 26. 32-pin QFN (5 × 5 × 0.55 mm) LQ32 3.5 × 3.5 E-Pad (Sawn) Package Outline, 001-42168**



| SYMBOL | DIMENSIONS |       |       |
|--------|------------|-------|-------|
|        | MIN.       | NOM.  | MAX.  |
| A      | 0.50       | 0.55  | 0.60  |
| A1     | -          | 0.020 | 0.045 |
| A2     | 0.15 BSC   |       |       |
| D      | 4.90       | 5.00  | 5.10  |
| D2     | 3.40       | 3.50  | 3.60  |
| E      | 4.90       | 5.00  | 5.10  |
| E2     | 3.40       | 3.50  | 3.60  |
| L      | 0.30       | 0.40  | 0.50  |
| b      | 0.18       | 0.25  | 0.30  |
| e      | 0.50 TYP   |       |       |

NOTES:

1.  HATCH AREA IS SOLDERABLE EXPOSED PAD
2. BASED ON REF JEDEC # MO-248
3. PACKAGE WEIGHT: 0.0388g
4. DIMENSIONS ARE IN MILLIMETERS

001-42168 \*F

## Appendix

**Table 22. Device Features vs. Resistor Configuration Matrix**

| Features   | Comments                                      |  | Pin configuration                             | Device Pin Name |
|--|---|--|---|-----------------|
| Toggle ON/OFF /<br>Flanking Sensor<br>Suppression (FSS)                | <b>Toggle ON/OFF</b>                          | <b>Flanking Sensor<br/>Suppression (FSS)</b>         |   | Toggle/FSS      |
|  | Disabled                                      | Disabled   | Ground / Floating                             |                 |
|  | Enabled                                       | Disabled   | 1.5 k $\Omega$ ( $\pm 5\%$ ) to ground        |                 |
|  | Disabled                                      | Enabled  | 5.1 k $\Omega$ ( $\pm 5\%$ ) to ground        |                 |
|  | Enabled                                       | Enabled  | V <sub>DD</sub>                               |                 |
| Noise Immunity / Button<br>Auto Reset                                  | <b>Noise Immunity</b>                         | <b>Button Auto Reset</b>                             |   | ARST/EMC        |
|  | Normal  | Disabled   | Ground / Floating                             |                 |
|  | Normal  | Enabled  | 1.5 k $\Omega$ ( $\pm 5\%$ ) to ground        |                 |
|  | High  | Disabled   | 5.1 k $\Omega$ ( $\pm 5\%$ ) to ground        |                 |
|  | High  | Enabled  | V <sub>DD</sub>                               |                 |
| LED ON Time / Serial<br>Debug Data                                     | <b>LED ON Time (ms)</b>                       | <b>Serial Debug Data</b>                             |   | Delay           |
|  | 0   | Disabled   | Ground / 300 $\Omega$ ( $\pm 1\%$ ) to ground |                 |
|  | 20  |  | 330 $\Omega$ ( $\pm 1\%$ ) to ground          |                 |
|  | 40  |  | 360 $\Omega$ ( $\pm 1\%$ ) to ground          |                 |
|  | .....   |  | .....   |                 |
|  | 1980  |  | 3270 $\Omega$ ( $\pm 1\%$ ) to ground         |                 |
|  | 2000  |  | 3300 $\Omega$ ( $\pm 1\%$ ) to ground         |                 |
|  | 0   | Enabled  | 7000 $\Omega$ ( $\pm 1\%$ ) to ground         |                 |
|  | 20  |  | 7030 $\Omega$ ( $\pm 1\%$ ) to ground         |                 |
|  | 40  |  | 7060 $\Omega$ ( $\pm 1\%$ ) to ground         |                 |
|  | .....   |  | .....   |                 |
|  | 1980  |  | 9970 $\Omega$ ( $\pm 1\%$ ) to ground         |                 |
|  | 2000  |  | 10000 $\Omega$ ( $\pm 1\%$ ) to ground        |                 |
| Power-on LED Effects /<br>Analog Voltage support /<br>LED Backlighting | <b>Power-on LED<br/>Effects</b>               | <b>Analog Voltage Support /<br/>LED Backlighting</b> |   | LEDFading       |
|  | Disabled                                      | Enabled  | Ground  |                 |
|  | LED Effect 1                                  | Disabled   | 1.5 k $\Omega$ ( $\pm 5\%$ ) to ground        |                 |
|  | LED Effect 2                                  | Disabled   | 5.1 k $\Omega$ ( $\pm 5\%$ ) to ground        |                 |
|  | LED Effect 3                                  | Disabled   | V <sub>DD</sub>                               |                 |
|  | Disabled                                      | Disabled   | Floating                                      |                 |
| Sensitivity and<br>debounce control for<br>CS0 button                  | <b>Sensitivity Control<br/>for CS0 Button</b> | <b>Debounce Control for CS0<br/>Button</b>           |   | CS0Sensitivity  |
|  | High  | 3  | Ground / Floating                             |                 |
|  | High  | 24   | 1.5 k $\Omega$ ( $\pm 5\%$ ) to ground        |                 |
|  | High  | 48   | 5.1 k $\Omega$ ( $\pm 5\%$ ) to ground        |                 |
|  | Low   | 99   | V <sub>DD</sub>                               |                 |

**Table 23. ScanRate/Sleep pin Configuration**

| ScanRate/Sleep pin Connection         |  | Button Scan Rate offset |
|---------------------------------------|--|-------------------------|
| Response Time Optimized design        | Power Consumption Optimized design     |                         |
| Ground                                | 6800 $\Omega$ ( $\pm 1\%$ ) to ground  | 0                       |
| 100 $\Omega$ ( $\pm 1\%$ ) to ground  | 6900 $\Omega$ ( $\pm 1\%$ ) to ground  | 0                       |
| 200 $\Omega$ ( $\pm 1\%$ ) to ground  | 7000 $\Omega$ ( $\pm 1\%$ ) to ground  | 6                       |
| 300 $\Omega$ ( $\pm 1\%$ ) to ground  | 7100 $\Omega$ ( $\pm 1\%$ ) to ground  | 12                      |
| 400 $\Omega$ ( $\pm 1\%$ ) to ground  | 7200 $\Omega$ ( $\pm 1\%$ ) to ground  | 20                      |
| 500 $\Omega$ ( $\pm 1\%$ ) to ground  | 7300 $\Omega$ ( $\pm 1\%$ ) to ground  | 29                      |
| 600 $\Omega$ ( $\pm 1\%$ ) to ground  | 7400 $\Omega$ ( $\pm 1\%$ ) to ground  | 39                      |
| 700 $\Omega$ ( $\pm 1\%$ ) to ground  | 7500 $\Omega$ ( $\pm 1\%$ ) to ground  | 49                      |
| 800 $\Omega$ ( $\pm 1\%$ ) to ground  | 7600 $\Omega$ ( $\pm 1\%$ ) to ground  | 61                      |
| 900 $\Omega$ ( $\pm 1\%$ ) to ground  | 7700 $\Omega$ ( $\pm 1\%$ ) to ground  | 73                      |
| 1000 $\Omega$ ( $\pm 1\%$ ) to ground | 7800 $\Omega$ ( $\pm 1\%$ ) to ground  | 86                      |
| 1100 $\Omega$ ( $\pm 1\%$ ) to ground | 7900 $\Omega$ ( $\pm 1\%$ ) to ground  | 99                      |
| 1200 $\Omega$ ( $\pm 1\%$ ) to ground | 8000 $\Omega$ ( $\pm 1\%$ ) to ground  | 114                     |
| 1300 $\Omega$ ( $\pm 1\%$ ) to ground | 8100 $\Omega$ ( $\pm 1\%$ ) to ground  | 128                     |
| 1400 $\Omega$ ( $\pm 1\%$ ) to ground | 8200 $\Omega$ ( $\pm 1\%$ ) to ground  | 144                     |
| 1500 $\Omega$ ( $\pm 1\%$ ) to ground | 8300 $\Omega$ ( $\pm 1\%$ ) to ground  | 160                     |
| 1600 $\Omega$ ( $\pm 1\%$ ) to ground | 8400 $\Omega$ ( $\pm 1\%$ ) to ground  | 176                     |
| 1700 $\Omega$ ( $\pm 1\%$ ) to ground | 8500 $\Omega$ ( $\pm 1\%$ ) to ground  | 194                     |
| 1800 $\Omega$ ( $\pm 1\%$ ) to ground | 8600 $\Omega$ ( $\pm 1\%$ ) to ground  | 211                     |
| 1900 $\Omega$ ( $\pm 1\%$ ) to ground | 8700 $\Omega$ ( $\pm 1\%$ ) to ground  | 229                     |
| 2000 $\Omega$ ( $\pm 1\%$ ) to ground | 8800 $\Omega$ ( $\pm 1\%$ ) to ground  | 248                     |
| 2100 $\Omega$ ( $\pm 1\%$ ) to ground | 8900 $\Omega$ ( $\pm 1\%$ ) to ground  | 267                     |
| 2200 $\Omega$ ( $\pm 1\%$ ) to ground | 9000 $\Omega$ ( $\pm 1\%$ ) to ground  | 287                     |
| 2300 $\Omega$ ( $\pm 1\%$ ) to ground | 9100 $\Omega$ ( $\pm 1\%$ ) to ground  | 307                     |
| 2400 $\Omega$ ( $\pm 1\%$ ) to ground | 9200 $\Omega$ ( $\pm 1\%$ ) to ground  | 327                     |
| 2500 $\Omega$ ( $\pm 1\%$ ) to ground | 9300 $\Omega$ ( $\pm 1\%$ ) to ground  | 348                     |
| 2600 $\Omega$ ( $\pm 1\%$ ) to ground | 9400 $\Omega$ ( $\pm 1\%$ ) to ground  | 369                     |
| 2700 $\Omega$ ( $\pm 1\%$ ) to ground | 9500 $\Omega$ ( $\pm 1\%$ ) to ground  | 391                     |
| 2800 $\Omega$ ( $\pm 1\%$ ) to ground | 9600 $\Omega$ ( $\pm 1\%$ ) to ground  | 413                     |
| 2900 $\Omega$ ( $\pm 1\%$ ) to ground | 9700 $\Omega$ ( $\pm 1\%$ ) to ground  | 436                     |
| 3000 $\Omega$ ( $\pm 1\%$ ) to ground | 9800 $\Omega$ ( $\pm 1\%$ ) to ground  | 459                     |
| 3100 $\Omega$ ( $\pm 1\%$ ) to ground | 9900 $\Omega$ ( $\pm 1\%$ ) to ground  | 482                     |
| 3200 $\Omega$ ( $\pm 1\%$ ) to ground | 10000 $\Omega$ ( $\pm 1\%$ ) to ground | 506                     |

Table 24 gives the Button Scan Rate constant according to the button count and the device optimization. For more details about this constant, refer [Power Consumption and Operating Modes on page 16](#).

**Table 24. Button Scan Rate Constant**

| Button count | Button Scan Rate Constant      |                                    |
|--------------|--------------------------------|------------------------------------|
|              | Response Time Optimized design | Power Consumption Optimized design |
| ≤ 5          | 25 ms                          | 50 ms                              |
| > 5          | 50 ms                          | 50 ms                              |

## Acronyms

| Acronym        | Description                 |
|----------------|-----------------------------|
| AC             | alternating current         |
| AI             | analog input                |
| AO             | analog output               |
| ARST           | auto reset                  |
| DC             | direct current              |
| DI             | digital input               |
| DO             | digital output              |
| C <sub>F</sub> | finger capacitance          |
| C <sub>P</sub> | parasitic capacitance       |
| CS             | CapSense                    |
| FSS            | flanking sensor suppression |
| GPO            | general-purpose output      |
| I/O            | input/output                |
| LED            | light-emitting diode        |
| LSB            | least significant bit       |
| MSB            | most significant bit        |
| P              | power                       |
| PCB            | printed circuit board       |
| POR            | power-on reset              |
| POST           | power-on self test          |
| QFN            | quad flat no lead           |
| RF             | radio frequency             |
| SNR            | signal to noise ratio       |

## Document Conventions

### Units of Measure

| Symbol | Unit of Measure                               |
|--------|---|
| °C     | degree Celsius                                |
| kΩ     | kilohm  |
| μA     | microampere                                   |
| μs     | microsecond                                   |
| mA     | milliampere                                   |
| mil    | one thousandth of an inch (1 mil = 0.0254 mm) |
| mm     | millimeter                                    |
| ms     | millisecond                                   |
| mV     | millivolt                                     |
| nA     | nanoampere                                    |
| nF     | nanofarad                                     |
| ns     | nanosecond                                    |
| Ω      | ohm   |
| %      | percent                                       |
| pF     | picofarad                                     |
| V      | volt  |

### Numeric Naming

Hexadecimal numbers are represented with all letters in uppercase with an appended lowercase 'h' (for example, '14h' or '3Ah'). Hexadecimal numbers may also be represented by a '0x' prefix, the C coding convention. Binary numbers have an appended lowercase 'b' (for example, '01010100b' or '01000011b'). Numbers not indicated by an 'h', 'b', or '0x' are decimal.

## Document History Page

| Document Title: CY8CMBR2010, CapSense® Express™ 10-Button Controller<br>Document Number: 001-74495 |         |                 |                 |  |
|--|---------|-----------------|-----------------|--|
| Revision   | ECN     | Orig. of Change | Submission Date | Description of Change  |
| **   | 3561834 | UDYG / ZINE     | 03/30/2012      | New data sheet.  |
| *A   | 3715110 | UDYG            | 08/16/2012      | Updated title to read as "CY8CMBR2010, CapSense® Express™ 10-Button Controller".<br>Updated <a href="#">Features</a> (Updated contents in the section).<br>Updated <a href="#">Functional Description</a> (Updated contents in the section).<br>Updated <a href="#">Pinout</a> (Updated <a href="#">Table 1</a> ).<br>Updated <a href="#">Typical Circuits</a> (Updated <a href="#">Figure 1</a> , <a href="#">Figure 2</a> , updated contents in the section).<br>Updated <a href="#">Device Features</a> (Updated contents in the section, updated <a href="#">Button Auto Reset</a> (Updated <a href="#">Figure 9</a> ), updated <a href="#">Analog Voltage Support</a> (Updated <a href="#">Figure 13</a> , <a href="#">Figure 14</a> )).<br>Updated <a href="#">Layout Guidelines and Best Practices</a> (Updated contents in the section, updated <a href="#">Example PCB Layout Design with Ten CapSense Buttons and Ten GPOs</a> (Updated <a href="#">Figure 24</a> , <a href="#">Figure 25</a> )).<br>Minor text edits throughout the document. |
| *B   | 3837617 | UDYG            | 12/11/2012      | Updated <a href="#">Device Features</a> (Updated <a href="#">System Diagnostics</a> (Updated <a href="#">Button Shorted to Ground</a> (Updated contents in the section and added <a href="#">Table 3</a> ))).  |
| *C   | 4722932 | DIMA            | 04/13/2015      | Updated <a href="#">Package Diagram</a> :<br>spec 001-42168 – Changed revision from *D to *E.<br>Updated to new template.<br>Completing Sunset Review.   |
| *D   | 6013708 | RRAM            | 01/04/2018      | Updated <a href="#">Package Diagram</a> :<br>spec 001-42168 – Changed revision from *E to *F.<br>Updated to new template.  |



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Мы предлагаем:

- Конкурентоспособные цены и скидки постоянным клиентам.
- Специальные условия для постоянных клиентов.
- Подбор аналогов.
- Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.
- Приемлемые сроки поставки, возможна ускоренная поставка.
- Доставку товара в любую точку России и стран СНГ.
- Комплексную поставку.
- Работу по проектам и поставку образцов.
- Формирование склада под заказчика.
- Сертификаты соответствия на поставляемую продукцию (по желанию клиента).
- Тестирование поставляемой продукции.
- Поставку компонентов, требующих военную и космическую приемку.
- Входной контроль качества.
- Наличие сертификата ISO.

В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.

Конструкторский отдел помогает осуществить:

- Регистрацию проекта у производителя компонентов.
- Техническую поддержку проекта.
- Защиту от снятия компонента с производства.
- Оценку стоимости проекта по компонентам.
- Изготовление тестовой платы монтаж и пусконаладочные работы.



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