

Features

- Easy to use capacitive button controller
 - Four-button solution configurable through Hardware straps
 - No software tools or programming required
 - Four general-purpose outputs (GPOs)
 - GPOs linked to CapSense® buttons
 - GPOs support direct LED drive
- Robust noise performance
 - Specifically designed for superior noise immunity to external radiated and conducted noise
 - Low radiated noise emission
- SmartSense™ Auto-Tuning
 - Saves time and effort in device tuning
 - CapSense parameters dynamically set in runtime
 - Maintains optimal button performance even in noisy environment
 - Wide parasitic capacitance C_P range (5 pF–40 pF)
- System Diagnostics of CapSense buttons - reports any faults at device power up
 - Button shorted to Ground
 - Button shorted to V_{DD}
 - Button to button short
 - Improper value of modulator capacitor (C_{MOD})
 - Parasitic capacitance (C_P) out of range
- Advanced features
 - Toggle ON/OFF feature on GPOs
 - Flanking Sensor Suppression (FSS) provides robust sensing even with closely spaced buttons
 - Configurable LED ON time after button release
 - Button output reset if touched for excessive time
 - User-controlled Button Scan Rate
 - 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
 - Supply current in run mode as low as 15 $\mu A^{[1]}$ per button
 - Deep sleep current: 100 nA
- Industrial temperature range: –40 °C to + 85 °C
- 16-pad quad flat no leads (QFN) package (3 mm × 3 mm × 0.6 mm)

Overview

The CY8CMBR2044 incorporates several innovative features to save time and money to quickly enable a capacitive touch sensing user interface in your design. It is a hardware configurable device and does not require any software tools or coding. 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 CY8CMBR2044 CapSense controller supports up to four capacitive touch sensing buttons and four General Purpose Outputs (GPOs). 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. Also, the same device can be used in different applications with different power supplies, including low power supplies.

This device supports ultra low-power consumption in both run mode and deep sleep mode 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.

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. Power consumption calculated with 1.7% touch time, 500 ms scan rate, and C_P of each sensor < 19 pF.

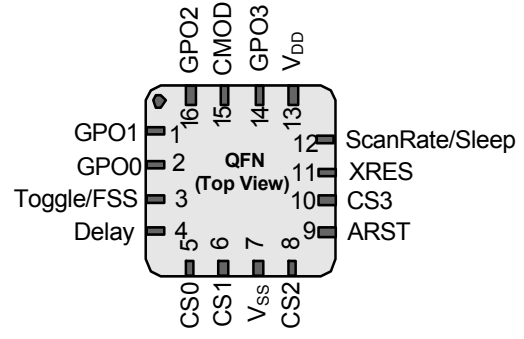
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Pinout

Table 1. Pin Diagram and Definitions – CY8CMBR2044

| Pin | Label | Type ^[2] | Description | If Unused |
|-----|------------------|---------------------|--|------------|
| 1 | GPO1 | DO | GPO activated by CS1 | Leave open |
| 2 | GPO0 | DO | GPO activated by CS0 | Leave open |
| 3 | Toggle/FSS | AI | Controls FSS and Toggle ON/OFF features | Ground |
| 4 | Delay | AI | Controls LED ON Time. For details refer to Table 2 on page 6 | Ground |
| 5 | CS0 | AIO | CapSense input, controls GPO0 or serial debug data out | Ground |
| 6 | CS1 | AIO | CapSense input, controls GPO1 or serial debug data out | Ground |
| 7 | V _{SS} | P | Ground | |
| 8 | CS2 | AIO | CapSense input, controls GPO2 or serial debug data out | Ground |
| 9 | ARST | AIDO | Controls Button Auto Reset | Leave open |
| 10 | CS3 | AIO | CapSense input, controls GPO3 or serial debug data out | Ground |
| 11 | XRES | DI | Device reset, active high, with internal pull down | Leave open |
| 12 | ScanRate / Sleep | AI | Controls scan rate and deep sleep | Ground |
| 13 | V _{DD} | P | Power | |
| 14 | GPO3 | DO | GPO activated by CS3 | Leave open |
| 15 | C _{MOD} | AI | External modulator capacitor, connect a 2.2 nF (±10%) to ground | |
| 16 | GPO2 | DO | GPO activated by CS2 | Leave open |

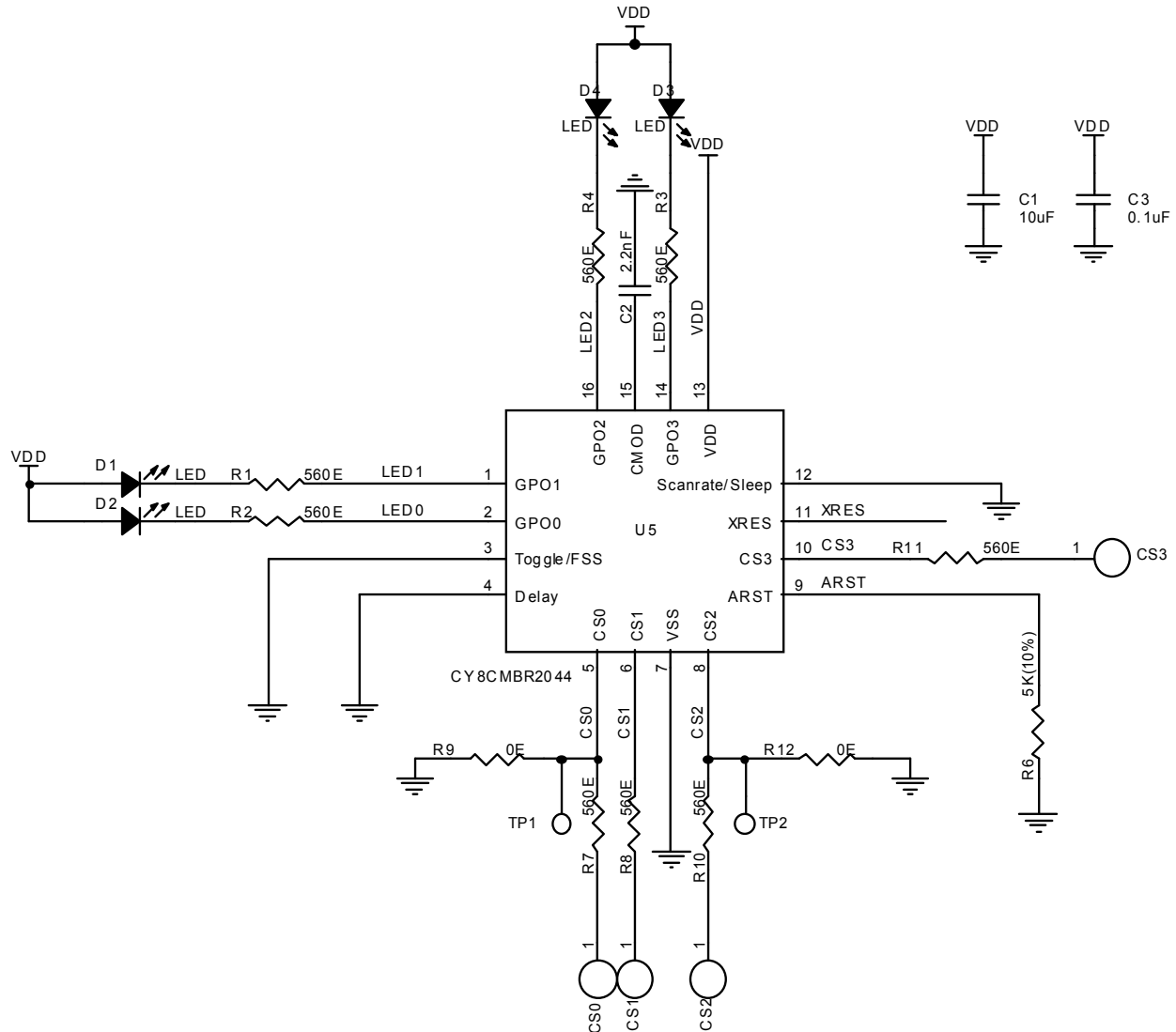


Note

2. AI – Analog Input, AIO – Analog Input / Output, AIDO – Analog Input / Digital Output, DI – Digital Input, DO – Digital Output, P – Power

Typical Circuits

Schematic 1: 4-Buttons, 4-LEDs with Auto Reset Enabled

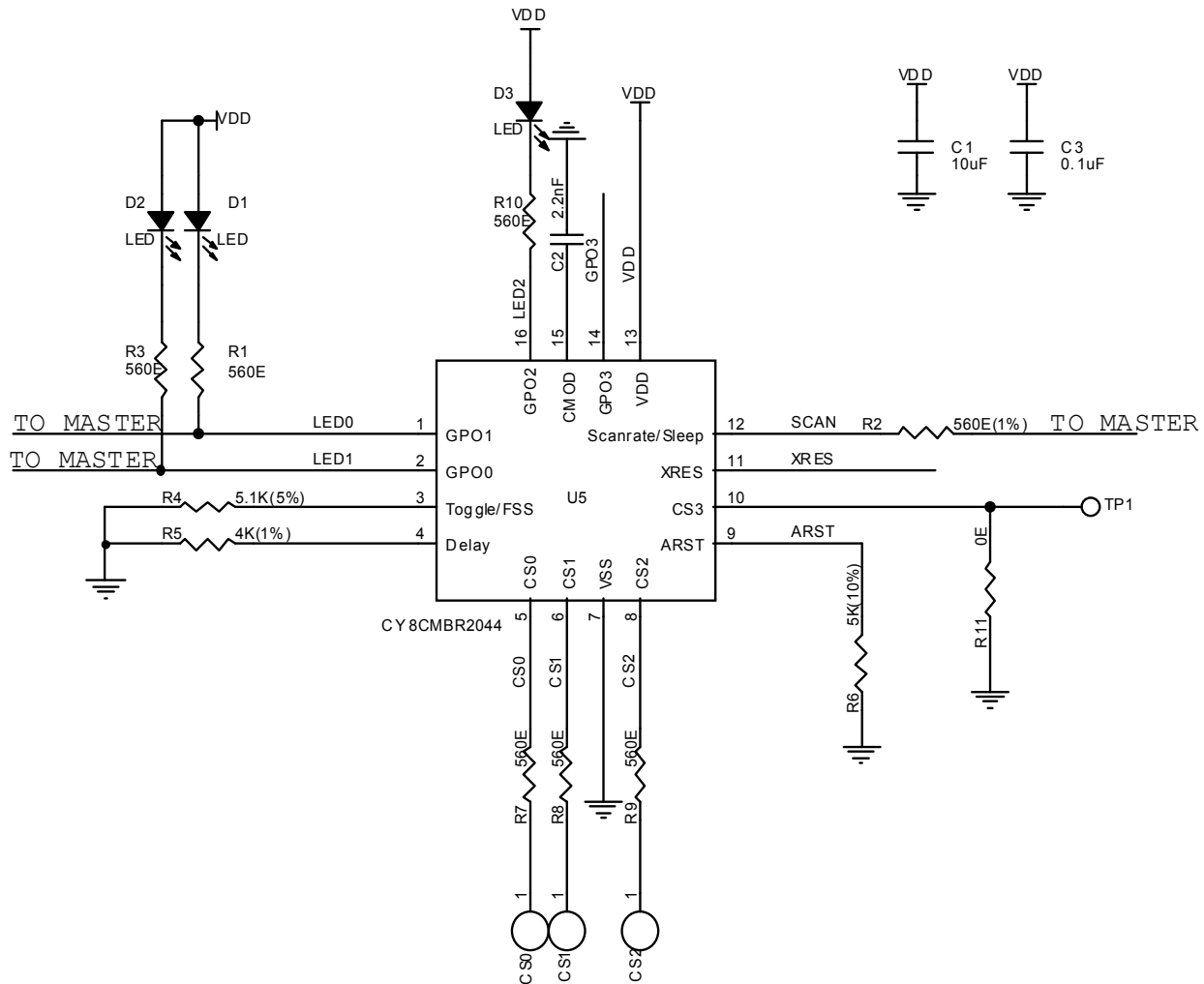


In the above schematic, the device is configured to support:

- CS0–CS3 pins: 560-Ω to CapSense button
 - Four CapSense buttons (CS0–CS3)
- GPO0–GPO3 pins: LED and 560-Ω to V_{DD}
 - CapSense buttons driving 4 LEDs (GPO0–GPO3)
- C_{MOD} pin: 2.2 nF to ground
 - Modulator capacitor
- XRES pin: Floating
 - For external reset

- Toggle/FSS pin: Ground
 - Toggle ON/OFF disabled
 - FSS disabled
- ARST pin: 5 kΩ to Ground
 - Button Auto Reset enabled, 20 second time
- Delay pin: Ground
 - LED ON Time disabled
- ScanRate/Sleep pin: Ground
 - User configured scan rate = 20 ms

To enable Serial Debug Data output, connect a 5.6 kΩ resistor on R9 or R12.

Schematic 2: 3-Buttons, 3-LEDs, 2-Outputs to Master, and Advanced Features Enabled


In the above schematic the device is configured to support:

- CS0–CS2 pins: 560-Ω to CapSense buttons; CS3 pin: Ground
 - Three CapSense buttons (CS0–CS2)
 - CS3 not used in design
- GPO0–GPO2 pins: LED and 560-Ω to VDD; GPO3 floating; GPO0–GPO1 pins interfaced to Master
 - CapSense buttons driving 3 LEDs (GPO0–GPO2)
 - GPO0, GPO1 interfaced to master for direct status read
- C_{MOD} 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
 - FSS enabled
 - ARST pin: 5 kΩ to Ground
 - Button Auto Reset enabled, Auto Reset period = 20 seconds
 - Delay pin: 4 kΩ to Ground
 - LED ON Time of 1000 ms
 - ScanRate/Sleep pin: 560 Ω to Master
 - User configured scan rate = 30 ms
 - Master to control device operating mode
- To enable Serial Debug Data output, connect a 5.6 kΩ resistor on R11.

Configuring the CY8CMBR2044

The CY8CMBR2044 device features are configured using external resistors.

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

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

To know more about the required settings for your design, refer to the [CY8CMBR2044 Design Guide](#).

Device Features

CapSense Buttons

- Device supports up to four CapSense buttons
- Ground the CSx pin to disable CapSense input
- A 2.2-nF ($\pm 10\%$) capacitor must be connected on the C_{MOD} pin for proper CapSense operation
- The parasitic Capacitance (C_P) of each button must be less than 40 pF for proper CapSense operation

SmartSense Auto Tuning

- Device supports auto tuning of CapSense parameters
- No manual tuning required; all parameters are automatically tuned by the device
- Compensates printed circuit board (PCB) variations, device process variations, and PCB vendor changes
- Ensures portability of the user interface design

General Purpose Outputs

- The GPOx is controlled by the corresponding CSx
- GPOx pins output are in strong drive mode ^[3]
- Active low output – supports sinking configuration
- If CSx is disabled (grounded), then the corresponding GPOx must be left floating
- A 5-ms active LOW pulse is sent after 175 ms after device power-up, on a GPOx after that it is set to Logic HIGH, if the CSx fails the System Diagnostics.
- GPOx pin outputs are in strong drive mode at logic level HIGH in Deep sleep power mode.
- GPOx pins output are in strong drive mode and retain the logic level same as before entering into low power sleep mode based on feature like (Toggle ,etc).
- All GPO pins are placed in a High-impedance state during reset i.e. XRES,POR.

Table 2. Advanced Features supported by CY8CMBR2044

| Feature | Benefits |
|--|---|
| Toggle ON/OFF | Button retains state on touch (ON/OFF) |
| Flanking Sensor Suppression (FSS) | Helps in distinguishing closely spaced buttons |
| LED ON Time | Gives an LED effect on button release |
| Button Auto Reset | Disables false output trigger due to conducting object placed close to button |
| System Diagnostics | Support for production testing and debugging |
| Serial Debug Data | Support for production testing and validating design |
| Low Power Sleep Mode and Deep Sleep Mode | Low power consumption |

Note

3. When a pin in in strong drive mode, it is pulled up to V_{DD} when the output is HIGH and pulled down to Ground when the output is LOW. The output cannot be floating.

Toggle ON/OFF

- Toggles the GPO state at each button touch.
- Used for mechanical button replacement. For example, wall switch.

Flanking Sensor Suppression (FSS)

- Helps to distinguish closely spaced buttons.
- Also used in situations when a button can produce opposite effects. For example, an interface with two buttons for brightness control (UP or DOWN).
- FSS action can be explained for the following different scenarios:
 - When only one button is touched, it is reported as ON.
 - 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.

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.
- When a button gets reset, LED ON Time is not applied on the corresponding GPO.
- In [Figure 3 on page 7](#), GPO0 goes high prematurely (prior to LED ON Time) 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 1. Example of Toggle Feature on GPO

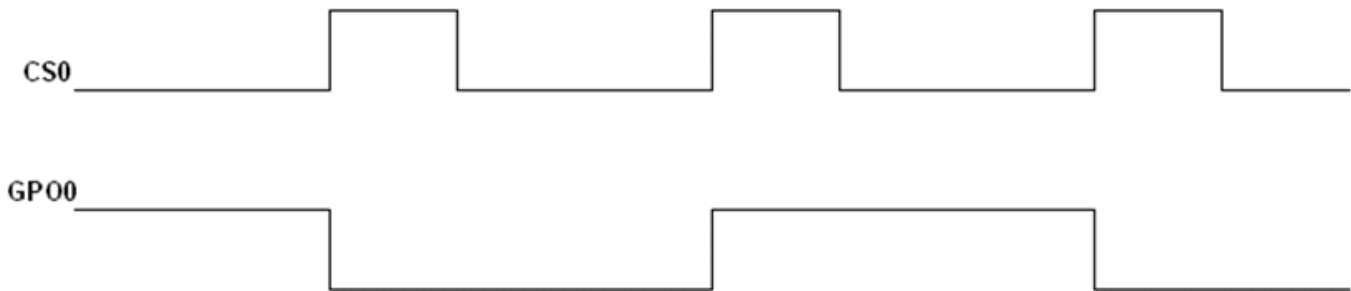


Figure 2. Button Status with Respect to Finger Touch when FSS is Enabled

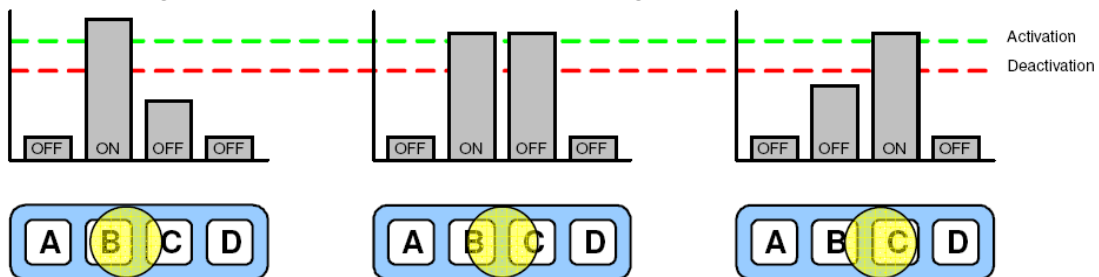


Figure 3. Example LED ON timing diagram on GPO0

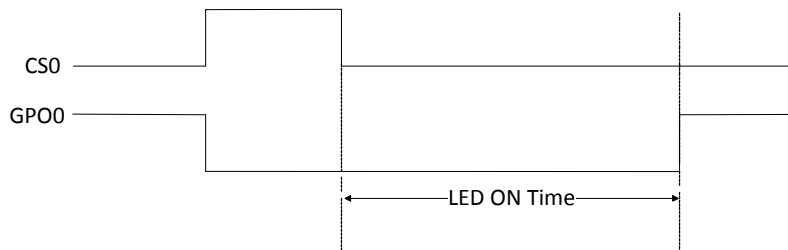
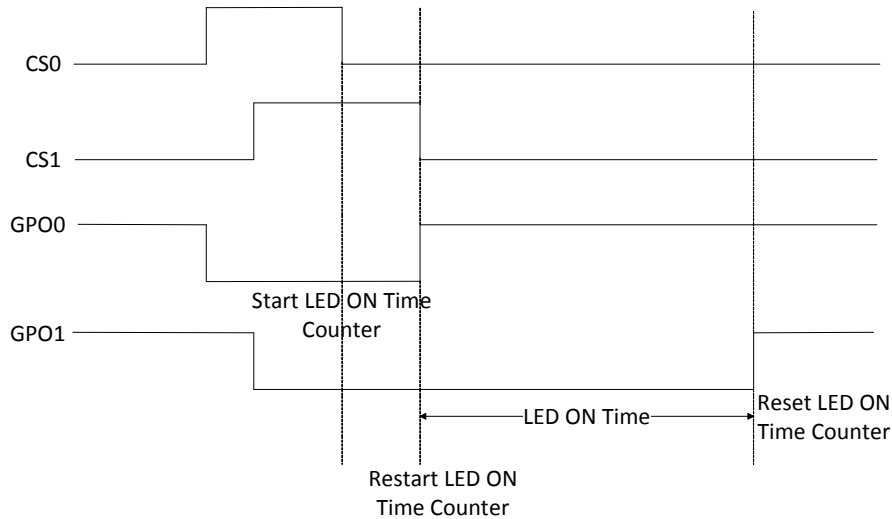


Figure 4. Example LED ON timing diagram on multiple GPO0 and GPO1



Button Auto Reset

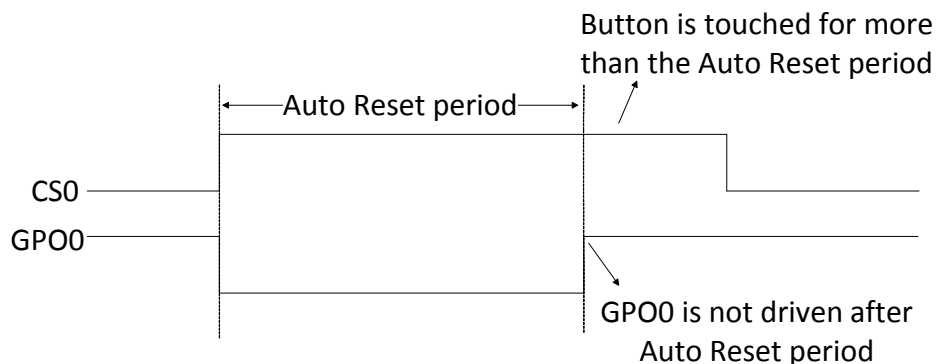
- Prevents button stuck, due to metal object placed close to a button.
- Useful when GPO output to be kept ON only for a specific time.
- If enabled, the GPOx is driven for a maximum of Button Auto Reset period when CSx is continuously touched. See [Figure 5 on page 8](#).

- Button Auto Reset period can be set to 5 or 20 seconds.
- After the Button Auto Reset has been triggered, the CSx hold time of that button after the button has been released is given in [Table 3](#). The hardware configuration is shown in [Table 15](#) in [Appendix](#).

Table 3. Button Hold Time After Auto Reset

| Button Press Time after Button Auto Reset | Button Hold Time (ms) |
|---|-----------------------|
| < 2 sec | 220 |
| > 2 sec | ScanRate + 200 |

Figure 5. Example of Button Auto Reset on GP0



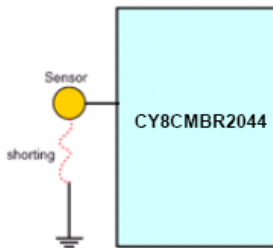
System Diagnostics

- 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 withing 175 ms 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. See Figure 6.

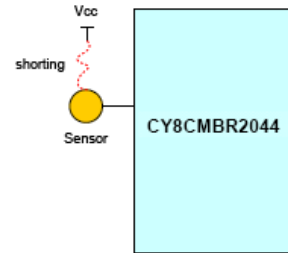
Figure 6. Button Shorted to Ground



Button Shorted to V_{DD}

If any button is found to be shorted to V_{DD}, it is disabled. See Figure 7.

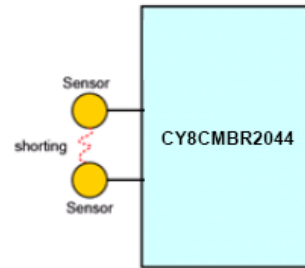
Figure 7. Button Shorted to VDD



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 8.

Figure 8. Button to Button Short

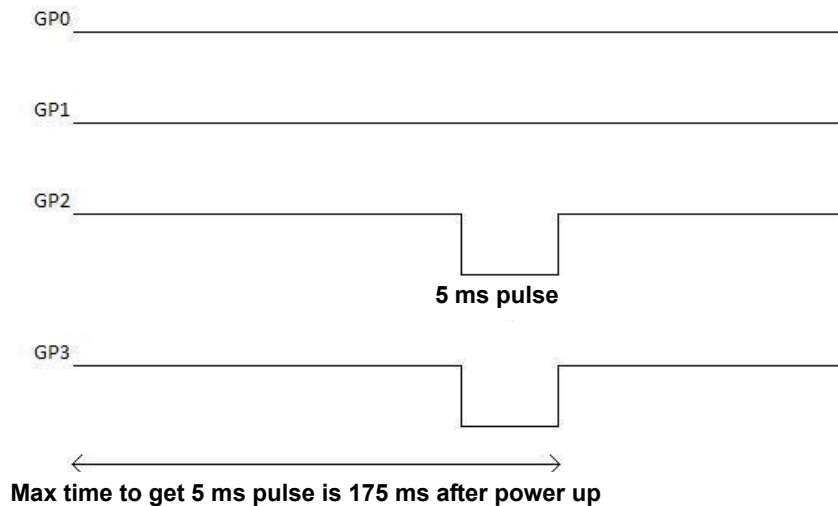


Improper Value of C_{MOD}

- 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 9. Example Showing CS0 and CS1 Passing the POST and CS2 and CS3 Failing


In Figure 9, 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 for debug purposes
- If enabled, debug data is transmitted using UART communication protocol.
- To enable this feature pull down any one of the CapSense pins with a 5.6 kΩ resistor to ground. Data is sent out on the same CapSense pin
- If more than one CapSense pin is pulled down, debug data is sent out only on one CapSense pin and the priority is CS0 > CS1 > CS2 > CS3
- The Cypress MultiChart tool can be used to view the data as a graph.
- Serial data is sent out with ~115,200 baud rate
- Firmware revision, CapSense status, GPO status, raw count, baseline, difference count, and parasitic capacitance of all sensors are sent out
- For designs having a maximum of three CapSense buttons, Cypress recommends to take the debug data on a CapSense button that is not used in design
- For designs with four CapSense buttons, Cypress recommends taking debug data on two CapSense buttons. For example, pull down CS0 with a 5.6 kΩ resistor and read data of CS1, CS2, and CS3. Next, pull down CS1 with a 5.6 kΩ resistor and read data of CS0, CS2, and CS3

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

- 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

| S.No. | Raw Count Array | | Baseline Array | | Signal Array | |
|-------|-----------------|-------------|----------------|------------|---------------|--------|
| | MSB | LSB | MSB | LSB | MSB | LSB |
| 0 | 0x00 | FW_Revision | CS_Status | GPO_Status | 0x00 | CS2_Cp |
| 1 | 0x00 | CS0_Cp | 0x00 | CS1_Cp | 0x00 | CS3_Cp |
| 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 | |

Table 5. Serial Data Output sent by CY8CMBR2044

| Byte | Data | Notes |
|------|-------------------|---|
| 0 | 0x0D | Dummy data for multi chart |
| 1 | 0x0A | |
| 2 | 0x00 | – |
| 3 | FW_Revision | – |
| 4 | 0x00 | – |
| 5 | CS0_Cp | CS0 parasitic capacitance 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 | – |
| 10 | CS2_RawCount_MSB | Unsigned 16-bit integer |
| 11 | CS2_RawCount_LSB | – |
| 12 | CS3_RawCount_MSB | Unsigned 16-bit integer |
| 13 | CS3_RawCount_LSB | – |
| 14 | CS_Status | Gives CapSense button status, least significant bit (LSB) contains CS0 status |
| 15 | GPO_Status | Gives GPO status, LSB contains GPO0 status |
| 16 | 0x00 | – |
| 17 | CS1_Cp | CS1 parasitic capacitance in Hex |
| 18 | CS0_Baseline_MSB | Unsigned 16-bit integer |
| 19 | CS0_Baseline_LSB | – |
| 20 | CS1_Baseline_MSB | Unsigned 16-bit integer |
| 21 | CS1_Baseline_LSB | – |
| 22 | CS2_Baseline_MSB | Unsigned 16-bit integer |
| 23 | CS2_Baseline_LSB | – |
| 24 | CS3_Baseline_MSB | Unsigned 16-bit integer |
| 25 | CS3_Baseline_LSB | – |
| 26 | 0x00 | – |
| 27 | CS2_Cp | CS2 parasitic capacitance in Hex |
| 28 | 0x00 | – |
| 29 | CS3_Cp | CS3 parasitic capacitance in Hex |
| 30 | CS0_DiffCount_MSB | Unsigned 16-bit integer |
| 31 | CS0_DiffCount_LSB | – |
| 32 | CS1_DiffCount_MSB | Unsigned 16-bit integer |
| 33 | CS1_DiffCount_LSB | – |
| 34 | CS2_DiffCount_MSB | Unsigned 16-bit integer |
| 35 | CS2_DiffCount_LSB | – |
| 36 | CS3_DiffCount_MSB | Unsigned 16-bit integer |
| 37 | CS3_DiffCount_LSB | – |
| 38 | 0x00 | Dummy data for multi chart |
| 39 | 0xFF | |
| 40 | 0xFF | |

Power Consumption and Device Operating Modes

The CY8CMBR2044 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 C_p using the design guidelines in [Getting Started with CapSense](#), section 3.7.1.
- Lower the supply voltage.
- Use a higher Button Scan Rate or Deep Sleep operating mode.

To know more about the steps to reduce power consumption, refer to [CY8CMBR2044 Design Guide](#), section 5.

There are two device operating modes:

- Low power sleep mode
- Deep sleep mode

Low Power Sleep Mode

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

Figure 10. Low Power Sleep Mode Operation

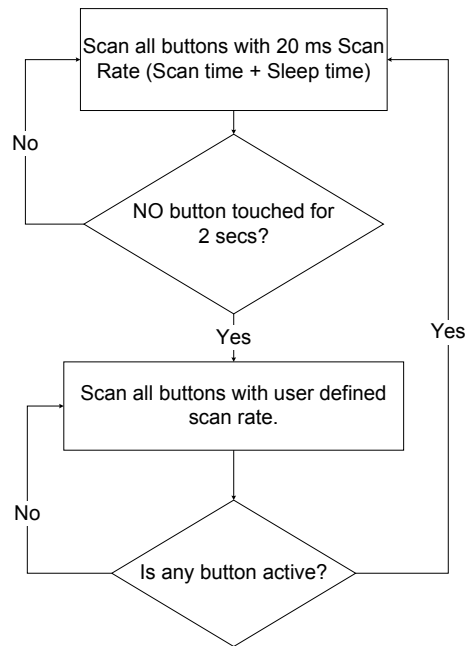
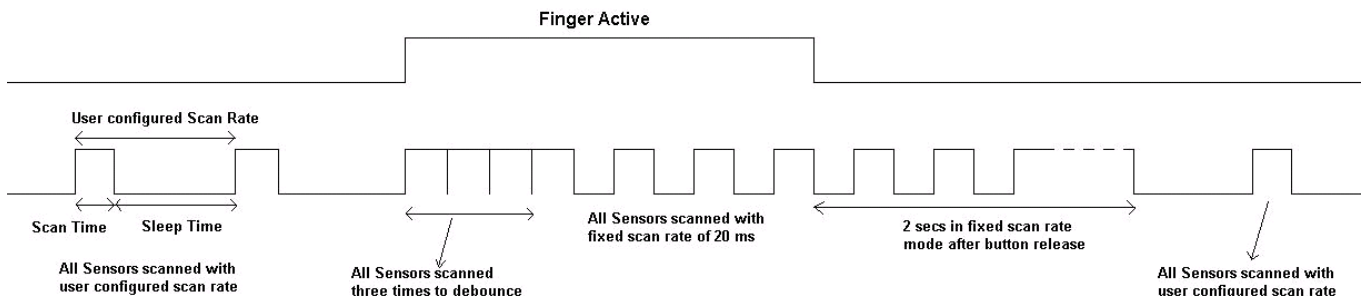
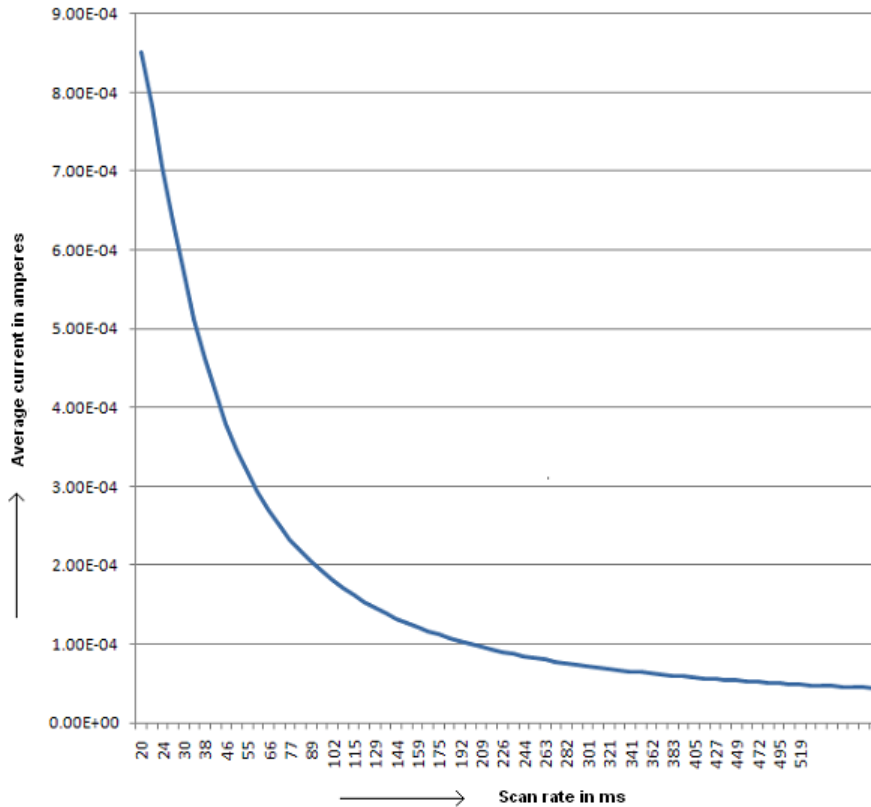


Figure 11. Low Power Sleep Mode Implementation



- To enable low power sleep mode, the hardware configurable pin ScanRate/Sleep should be pulled down to ground with resistor 'R' (1%). The scan rate values for different resistor values are given in Table 15 in Appendix.
- If the ScanRate/Sleep pin is pulled to ground without any resistor, the Button Scan Rate is set to 20 ms. The device operates in low power sleep mode, unless a button is touched.
- The range of scan rate is 20 to 530 ms.

Figure 12. Average Current vs Scan Rate ^[4]

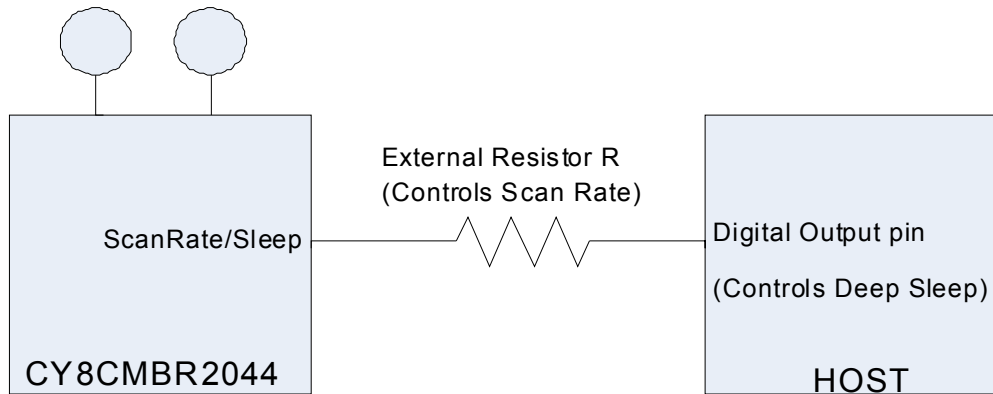


Note

4. Number of sensors = 3, Cp < 19 pF, 0% touch time, V_{DD} = 3 V.

Deep Sleep Mode

Figure 13. ScanRate/Sleep Pin Connection to Enable Deep Sleep Mode



- To enable the deep sleep mode, the hardware configuration pin ScanRate/Sleep should be connected to the master device as shown in [Figure 13](#).
- Host controller should pull the pin to V_{DD} for the device to go into deep sleep.
- The Host controller output pin should be in Strong drive mode, so that the ScanRate/Sleep pin is not left floating.
- In deep sleep mode, all blocks are turned off and the device current consumption is approximately $0.1 \mu A$.
- 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 8 ms. Any button touch within this time is not reported.
- After the device comes out of deep sleep, the device operates in low power sleep mode.
- If the ScanRate/Sleep pin is pulled high at power on, then the device does not go to deep sleep immediately. The device goes to deep sleep after initializing all internal blocks and scanning all buttons once.
- If the ScanRate/Sleep pin is pulled high at power on, then the button scan rate is calculated when the device is taken out of Deep Sleep by the master.

Additional Components to Enable Advanced Features

| S.No. | Feature | Resistors required | Notes |
|-------|--------------------------------|--------------------|--|
| 1 | Low power sleep and deep sleep | 1 | Deep sleep is controlled by a master device. When the device comes out of deep sleep, it enters into low power sleep mode based on settings. Resistor is not required if both features are not used. |
| 2 | Toggle/FSS | 1 | To enable both the features only one resistor is required. Resistor is not required if both features are not used. |
| 3 | Delay Off | 1 | Resistor is not required if the feature is not used. |
| 4 | Sensor auto reset | 1 | Resistor is not required if the feature is not used. |

Response Time

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

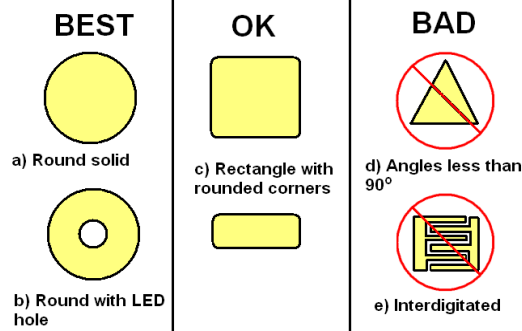
| Condition | Response time (in ms) |
|---|---|
| First button press | Button Scan rate value + 20. For button scan rate value, see Table 15 in Appendix . |
| Consecutive button press after first button press | 80 |

Layout Guidelines and Best Practices

| S.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 Design Toolbox |
| 3 | Button-button spacing | Equal to Button Ground Clearance | – | 8 mm (Y dimension in Button Layout Design on page 16) |
| 4 | Button ground clearance | 0.5 mm | 2 mm | Refer Design Toolbox (X dimension in Button Layout Design on page 16) |
| 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 Design Toolbox |
| 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 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 and bottom layer – device, other components and traces |
| 17 | Placement of components in four layer PCB | – | – | Top layer – buttons, second layer – CapSense traces and V _{DD} (avoid V _{DD} traces below the buttons), third layer – hatched ground, bottom layer – CapSense IC or device, other components, and non CapSense traces |
| 18 | Overlay thickness | 0 mm | 5 mm | Refer Design Toolbox |
| 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 Example PCB Layout Design with Four CapSense Buttons and Four LEDs on page 17 |
| 22 | Board thickness | – | – | Standard board thickness for CapSense FR4 based designs is 1.6 mm. |

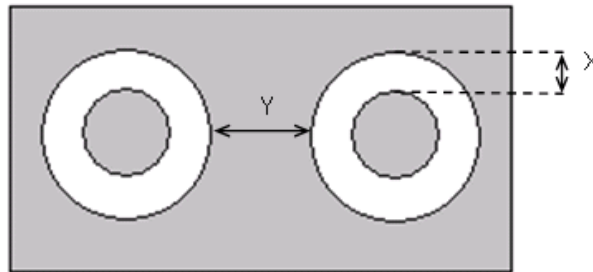
CapSense Button Shapes

Figure 14. CapSense Button Shapes



Button Layout Design

Figure 15. Button Layout Design

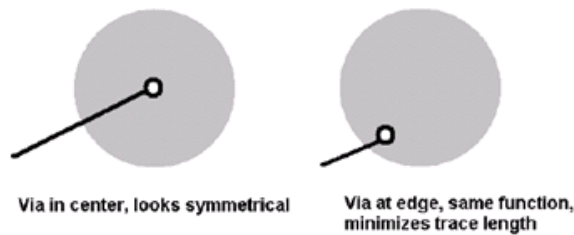


X: Button to ground clearance (Refer to [Layout Guidelines and Best Practices on page 15](#))

Y: Button to button clearance (Refer to [Layout Guidelines and Best Practices on page 15](#))

Recommended Via Hole Placement

Figure 16. Recommended Via Hole Placement



Example PCB Layout Design with Four CapSense Buttons and Four LEDs

Figure 17. Top Layer

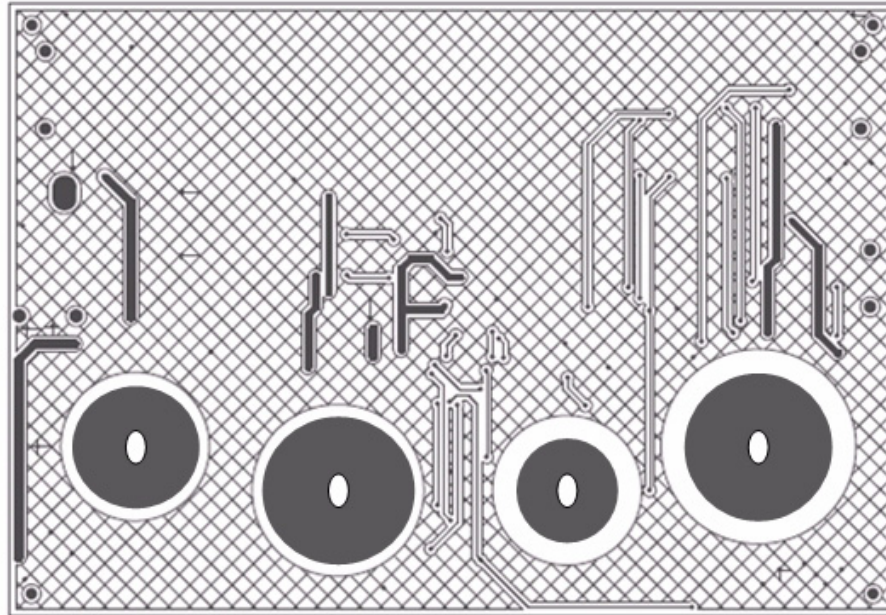
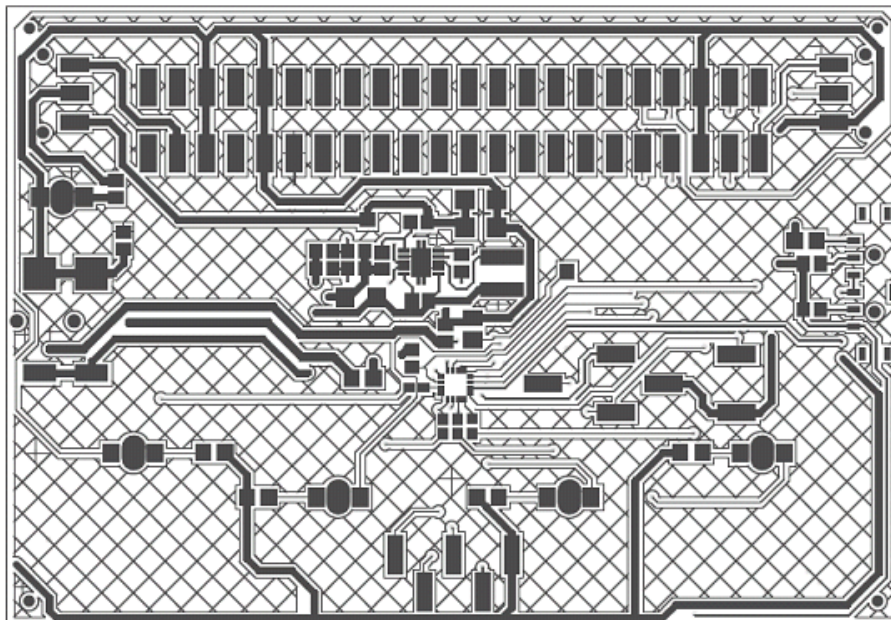


Figure 18. Bottom Layer



Electrical Specifications

This section presents the DC and AC electrical specifications of the CY8CMBR2044 device.

Absolute Maximum Ratings

Table 6. Absolute Maximum Ratings

| Parameter | Description | Min | Typ | Max | Unit | Notes |
|------------------|---|-----------------------|-----|-----------------------|------|---|
| T _{STG} | Storage temperature | -55 | 25 | +125 | °C | Higher storage temperatures reduce data retention time. Recommended storage temperature is +25 °C ± 25 °C. Extended duration storage temperatures above 85 °C degrades reliability. |
| V _{DD} | Supply voltage relative to V _{SS} | -0.5 | - | +6.0 | V | |
| V _{IO} | DC voltage on CapSense inputs and digital output pins | V _{SS} - 0.5 | - | V _{DD} + 0.5 | V | |
| I _{MIG} | Maximum current into any GPO output 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 7. Operating Temperature

| Parameter | Description | Min | Typ | Max | Unit | Notes |
|----------------|-----------------------------|-----|-----|------|------|-------|
| T _A | Ambient temperature | -40 | - | +85 | °C | |
| T _J | Operational die temperature | -40 | - | +100 | °C | |

DC Electrical Characteristics

DC Chip Level Specifications

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

Table 8. DC Chip Level Specifications

| Parameter | Description | Min | Typ | Max | Unit | Notes |
|----------------------|--------------------|------|------|-----|---------------|--|
| $V_{DD}^{[5, 6, 7]}$ | Supply voltage | 1.71 | – | 5.5 | V | |
| I_{DD} | Supply current | – | 2.88 | 4.0 | mA | Conditions are $V_{DD} = 3.0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$ |
| I_{DA} | Active current | – | 2.88 | 4.0 | mA | Conditions are $V_{DD} = 3.0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, continuous sensor scan |
| I_{DS} | Deep sleep current | – | 0.1 | 0.5 | μA | Conditions are $V_{DD} = 3.0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$ |
| I_{AV1} | Average current | – | 40 | – | μA | Conditions are $V_{DD} = 3.0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, 4 – buttons used, 0% touch time, C_P of all sensors < 19 pF and scan rate = 530 ms |
| I_{AV2} | Average current | – | 63 | – | μA | Conditions are $V_{DD} = 3.0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, 4 – buttons used, 0% touch time, C_P of all sensors > 19 pF and scan rate = 530 ms |
| I_{AV3} | Average current | – | 1 | – | mA | Conditions are $V_{DD} = 3.0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, 4 – buttons used, 100% touch time, C_P of all sensors < 19 pF and scan rate = 20 ms |
| I_{AV4} | Average current | – | 1.6 | – | mA | Conditions are $V_{DD} = 3.0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, 4 – buttons used, 100% touch time, C_P of all sensors > 19 pF and < 40 pF, scan rate = 20 ms |

Notes

- When V_{DD} remains in the range from 1.75 V to 1.9 V for more than 50 μs , 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 μs . This helps to avoid triggering POR. The only other restriction on slew rates for any other voltage range or transition is the SR_{POWER_UP} parameter.
- After power down, ensure that V_{DD} falls below 100 mV before powering backup.
- 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 $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, 2.4 V to 3.0 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 1.71 V to 2.4 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 9. 3.0 V to 5 V DC General Purpose I/O Specifications

| Parameter ^[8] | Description | Min | Typ | Max | Unit | Notes |
|--------------------------|---|-----------------------|-----|------|------|--|
| V _{OH1} | High output voltage on GP0, GP1, GP2, GP3 | V _{DD} - 0.2 | – | – | V | I _{OH} < 10 μA, maximum of 40 μA source current in all I/Os |
| V _{OH2} | High output voltage on GP0, GP1 | V _{DD} - 0.9 | – | – | V | I _{OH} = 1 mA, maximum of 2 mA source current in all I/Os |
| V _{OH3} | High output voltage on GP2, GP3 | V _{DD} - 0.9 | – | – | V | I _{OH} = 5 mA, maximum of 10 mA source current in all I/Os |
| V _{OL} | Low output voltage | – | – | 0.75 | V | I _{OL} = 25 mA/pin, V _{DD} > 3.30, maximum of 60 mA sink current on GPO0, GPO1, GPO2, GPO3 |

Table 10. 2.4 V to 3.0 V DC General Purpose I/O Specifications

| Parameter ^[8] | Description | Min | Typ | Max | Unit | Notes |
|--------------------------|---|-----------------------|-----|------|------|--|
| V _{OH1} | High output voltage on GP0, GP1, GP2, GP3 | V _{DD} - 0.2 | – | – | V | I _{OH} < 10 μA, maximum of 40 μA source current in all I/Os |
| V _{OH2} | High output voltage on GP0, GP1 | V _{DD} - 0.4 | – | – | V | I _{OH} = 0.2 mA, maximum of 0.4 mA source current in all I/Os |
| V _{OH3} | High output voltage on GP2, GP3 | V _{DD} - 0.5 | – | – | V | I _{OH} = 2 mA, maximum of 4 mA source current in all I/Os |
| V _{OL} | Low output voltage | – | – | 0.72 | V | I _{OL} = 10 mA/pin, maximum of 30 mA sink current on GPO0, GPO1, GPO2, GPO3 |

Table 11. 1.71 V to 2.4 V DC General Purpose I/O Specifications

| Parameter ^[8] | Description | Min | Typ | Max | Unit | Notes |
|--------------------------|---------------------------------|-----------------------|-----|-----|------|---|
| V _{OH1} | High output voltage on GP0, GP1 | V _{DD} - 0.2 | – | – | V | I _{OH} = 10 μA, maximum of 20 μA source current in all I/Os |
| V _{OH2} | High output voltage on GP0, GP1 | V _{DD} - 0.5 | – | – | V | I _{OH} = 0.5 mA, maximum of 1 mA source current in all I/Os |
| V _{OH3} | High output voltage on GP2, GP3 | V _{DD} - 0.2 | – | – | V | I _{OH} = 100 μA, maximum of 200 μA source current in all I/Os |
| V _{OH4} | High output voltage on GP2, GP3 | V _{DD} - 0.5 | – | – | V | I _{OH} = 2 mA, maximum of 4 mA source current in all I/Os |
| V _{OL} | Low output voltage | – | – | 0.4 | V | I _{OL} = 5 mA/pin, maximum of 20 mA sink current on GPO0, GPO1, GPO2, GPO3 |

Note

8. XRES pin input voltage ranges at various DC Specifications (VDD) listed below:
 Minimum Input voltage for reset is 2V at 3.0 V to 5.5 V.
 Minimum Input voltage for reset is 1.4V at 2.4 V to 3.0 V.
 Minimum Input voltage for reset is 0.65 × VDD at 1.71 V to 2.4 V.

AC Electrical Specifications

AC Chip-Level Specifications

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

| Parameter | Description | Min | Max | Unit | Notes |
|------------------------|---|-----|-----|------|---|
| SR _{POWER_UP} | Power supply slew rate | – | 250 | V/ms | V _{DD} slew rate during power up |
| T _{XRST} | External reset pulse width at power up | 1 | – | ms | After supply voltage is valid |
| T _{XRST2} | External reset pulse width after power-up | 10 | – | μs | Applies after part has booted |

AC General Purpose I/O Specifications

| Parameter | Description | Min | Typ | Max | Unit | Notes |
|-----------|---|-----|-----|-----|------|--|
| TRise1 | Rise time on GPO0 and GPO1, Cload = 50 pF | 15 | – | 80 | ns | V _{DD} = 3.0 to 3.6 V, 10% – 90% |
| TRise2 | Rise time on GPO2 and GPO3, Cload = 50 pF | 10 | – | 50 | ns | V _{DD} = 3.0 to 3.6 V, 10% – 90% |
| TRise3 | Rise time on GPO0 and GPO1, Cload = 50 pF | 15 | – | 80 | ns | V _{DD} = 1.71 to 3.0V, 10% – 90% |
| TRise2 | Rise time on GPO2 and GPO3, Cload = 50 pF | 10 | – | 80 | ns | V _{DD} = 1.71 to 3.0 V, 10% – 90% |
| TRise4 | Fall time, Cload=50 pF all GPO outputs | 10 | – | 50 | ns | V _{DD} = 3.0 to 3.6 V, 90% – 10% |
| TFall2 | Fall time, Cload=50 pF all GPO outputs | 10 | – | 70 | ns | V _{DD} = 1.71 to 3.0 V, 90% – 10% |

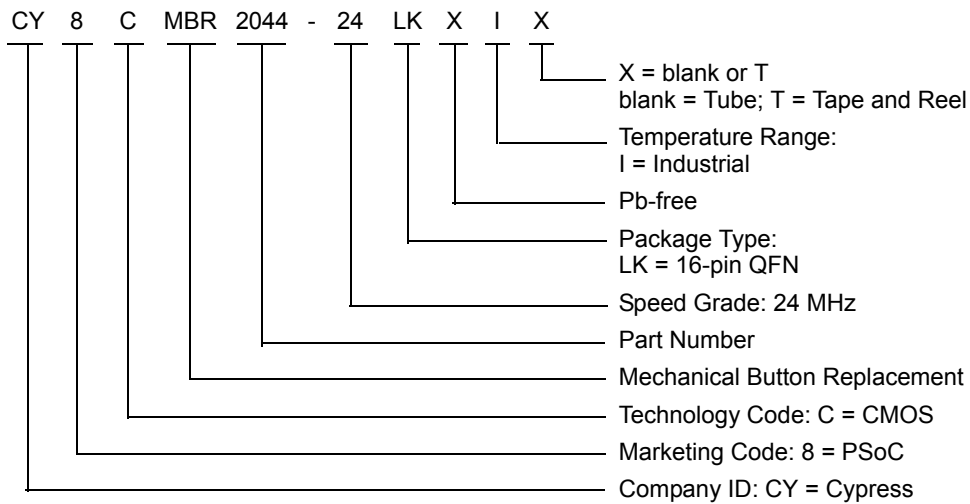
CapSense Specifications

| Parameter | Description | Min | Typ | Max | Unit | Notes |
|------------------|--|------|-----|--------------------------------------|------|---|
| C _P | Parasitic capacitance | 5.0 | – | (C _P +C _F)<40 | 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 | 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 for CapSense to work |
| Rs | Series resistor between pin and the sensor | – | 560 | 616 | Ω | Reduces the RF noise |

Ordering Information

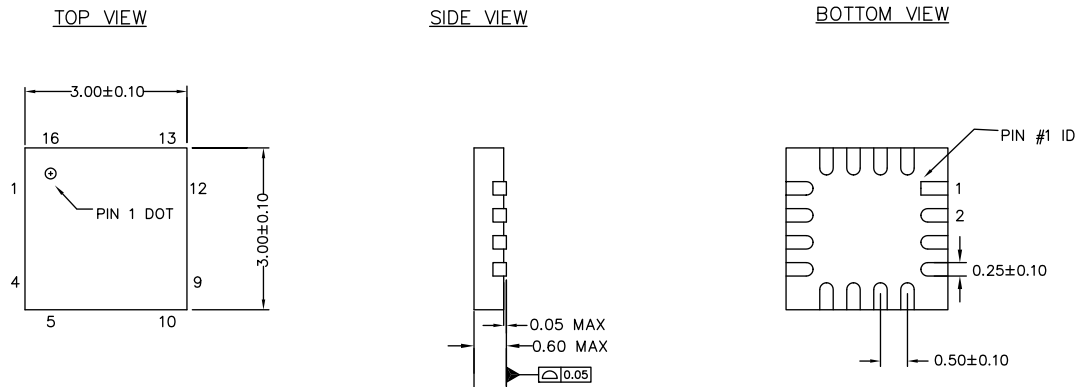
| Ordering Code | Package Type | Operating Temperature | CapSense Inputs | GPOs | XRES Pin |
|---------------------|---|-----------------------|-----------------|------|----------|
| CY8CMBR2044-24LKXI | 16-pin QFN (3 × 3 × 0.6 mm) | Industrial | 4 | 4 | Yes |
| CY8CMBR2044-24LKXIT | 16-pin QFN (3 × 3 × 0.6 mm) (Tape and Reel) | Industrial | 4 | 4 | Yes |

Ordering Code Definitions



Package Diagram

Figure 19. 16-pin Chip On Lead (3 × 3 × 0.6 mm) LG16A/LD16A (Sawn) Package Outline, 001-09116



NOTES

1. REFERENCE JEDEC # MO-220
2. PACKAGE WEIGHT: 14 ± 1 mg
3. ALL DIMENSIONS ARE IN MILLIMETERS

001-09116 *G

Package Information

Table 12. Thermal Impedances by Package

| Package | Typical θ_{JA} [9] |
|------------|---------------------------|
| 16-pin QFN | 32.7 °C/W |

Table 13. Solder Reflow Peak Temperature

| Package | Minimum Peak Temperature [10] | Maximum Peak Temperature |
|------------|-------------------------------|--------------------------|
| 16-pin QFN | 240 °C | 260 °C |

Notes

9. $T_J = T_A + \text{Power} \times \theta_{JA}$

10. Higher temperatures may be required based on the solder melting point. Typical temperatures for solder are 220 ± 5 °C with Sn-Pb or 245 ± 5 °C with Sn-Ag-Cu paste. Refer to the solder manufacturer specifications.

Appendix

Table 14. Device Features vs. Resistor Configuration Matrix

| Features | Comments | | Pin Configuration | Device Pin Name |
|---|------------------------------------|------------|--------------------------|-----------------|
| Button Auto Reset | Enabled, Auto Reset Period = 5 ms | | Ground / Floating | ARST |
| | Enabled, Auto Reset Period = 20 ms | | 5.1 kΩ (±5%) to ground | |
| | Disabled | | VDD | |
| LED ON Time | 0 ms | | Ground | Delay |
| | 20 ms | | 120 Ω (±1%) to ground | |
| | 40 ms | | 200 Ω (±1%) to ground | |
| | 60 ms | | 280 Ω (±1%) to ground | |
| | | | | |
| | 1980 ms | | 7060 Ω (±1%) to ground | |
| | 2000 ms | | 8040 Ω (±1%) to ground | |
| | 2000 ms | | > 8040 Ω (±1%) to ground | |
| | 2000 ms | | VDD / Floating | |
| Toggle ON/OFF / Flanking Sensor Suppression (FSS) | Toggle ON/OFF | FSS | | Toggle/FSS |
| | Disabled | Disabled | Ground / Floating | |
| | Enabled | Disabled | 1.5 kΩ (±5%) to ground | |
| | Disabled | Enabled | 5.1 kΩ (±5%) to ground | |
| | Enabled | Enabled | VDD | |

Table 15. ScanRate/Sleep Pin Hardware Configuration

| Resistor R (1%) in ohms | Approximate ScanRate (in ms) | Resistor R (1%) in ohms | Approximate ScanRate (in ms) |
|-------------------------|------------------------------|-------------------------|------------------------------|
| 60 | 20 | 4060 | 209 |
| 185 | 22 | 4185 | 217 |
| 310 | 24 | 4310 | 226 |
| 435 | 27 | 4435 | 235 |
| 560 | 30 | 4560 | 244 |
| 685 | 34 | 4685 | 253 |
| 810 | 38 | 4810 | 263 |
| 935 | 42 | 4935 | 272 |
| 1060 | 46 | 5060 | 282 |
| 1185 | 51 | 5185 | 291 |
| 1310 | 55 | 5310 | 301 |
| 1435 | 61 | 5435 | 311 |
| 1560 | 66 | 5560 | 321 |
| 1685 | 71 | 5685 | 331 |
| 1810 | 77 | 5810 | 341 |
| 1935 | 83 | 5935 | 352 |
| 2060 | 89 | 6060 | 362 |
| 2185 | 96 | 6185 | 373 |
| 2310 | 102 | 6310 | 383 |
| 2435 | 107 | 6435 | 394 |
| 2560 | 115 | 6560 | 405 |
| 2685 | 122 | 6685 | 416 |
| 2810 | 129 | 6810 | 427 |
| 2935 | 137 | 6935 | 438 |
| 3060 | 144 | 7060 | 449 |
| 3185 | 152 | 7185 | 461 |
| 3310 | 159 | 7310 | 472 |
| 3435 | 167 | 7435 | 484 |
| 3560 | 175 | 7560 | 495 |
| 3685 | 183 | 7685 | 507 |
| 3810 | 192 | 7810 | 519 |
| 3935 | 200 | 7935 | 531 |

Acronyms

| Acronym | Description |
|----------------|-----------------------------|
| AC | alternating current |
| AI | analog input |
| AIO | analog input/output |
| AIDO | analog input/digital output |
| DO | digital output |
| P | power pins |
| C _F | finger capacitance |
| C _P | parasitic capacitance |
| CS | capsense |
| FSS | flanking sensor suppression |
| GPO | general purpose output |
| LSB | least significant bit |
| MSB | most significant bit |
| PCB | printed circuit board |
| POR | power on reset |
| POST | power on self test |
| RF | radio frequency |

Document Conventions

Units of Measure

| Symbol | Unit of Measure |
|--------|-----------------|
| °C | degree Celsius |
| kΩ | kilohm |
| μA | microampere |
| μs | microsecond |
| mA | milliampere |
| ms | millisecond |
| mV | millivolt |
| nA | nanoampere |
| Ω | ohm |
| 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: CY8CMBR2044, Four Button CapSense® Controller Document Number: 001-57451 | | | | |
|---|---------|-----------------|-----------------|--|
| Rev. | ECN No. | Orig. of Change | Submission Date | Description of Change |
| ** | 2807997 | SLAN | 12/03/2009 | New data sheet. |
| *A | 2949368 | SLAN | 06/10/2010 | Updated Features . Updated Overview . Updated Pinout . Updated Typical Circuits (Updated Schematic 1: 4-Buttons, 4-LEDs with Auto Reset Enabled and Schematic 2: 3-Buttons, 3-LEDs, 2-Outputs to Master, and Advanced Features Enabled). Updated Device Features (Added Table 2 , updated Hardware Configuration (description), updated Flanking Sensor Suppression (FSS) (Added Figure 2), updated System Diagnostics (Added Figure 6 , and Figure 8), added Serial Debug Data). Updated Power Consumption and Device Operating Modes (Updated Deep Sleep Mode (description)). Updated Layout Guidelines and Best Practices (Updated CapSense Button Shapes , updated Example PCB Layout Design with Four CapSense Buttons and Four LEDs). Updated Electrical Specifications . Added Ordering Code Definitions . Added Units of Measure . |
| *B | 2975370 | SLAN | 07/09/2010 | Updated Features . Updated Pinout . Updated Typical Circuits . Updated Device Features (Updated LED ON Time (Updated Figure 4), updated System Diagnostics (Updated Figure 6 , and Figure 8), updated Serial Debug Data (description)). Updated Power Consumption and Device Operating Modes (Updated Deep Sleep Mode (description)). |
| *C | 2996393 | SLAN | 07/29/2010 | Updated Features . |
| *D | 3036873 | ARVM | 09/23/2010 | Updated Typical Circuits (Updated Schematic 1: 4-Buttons, 4-LEDs with Auto Reset Enabled and Schematic 2: 3-Buttons, 3-LEDs, 2-Outputs to Master, and Advanced Features Enabled). Updated Layout Guidelines and Best Practices (Updated Example PCB Layout Design with Four CapSense Buttons and Four LEDs (Updated Figure 17)). |

Document History Page (continued)

| Document Title: CY8CMBR2044, Four Button CapSense® Controller Document Number: 001-57451 | | | | |
|---|---------|-----------------|-----------------|--|
| Rev. | ECN No. | Orig. of Change | Submission Date | Description of Change |
| *E | 3624224 | UDYG / SLAN | 05/22/2012 | <p>Updated Title to read as “Four Button CapSense® Controller”.</p> <p>Updated Features.</p> <p>Updated Overview.</p> <p>Updated Pinout (Updated Table 1).</p> <p>Updated Typical Circuits (Updated Schematic 1: 4-Buttons, 4-LEDs with Auto Reset Enabled and Schematic 2: 3-Buttons, 3-LEDs, 2-Outputs to Master, and Advanced Features Enabled).</p> <p>Updated Device Features (Updated Table 2, updated CapSense Buttons, updated SmartSense Auto Tuning, updated General Purpose Outputs, removed Hardware Configuration, updated Toggle ON/OFF, updated Flanking Sensor Suppression (FSS), removed Delay Off, added LED ON Time, updated Button Auto Reset, renamed Failure Mode Analysis as System Diagnostics and updated the same section, renamed Debug Data as Serial Debug Data and updated the same section, renamed Device Operating Modes as Power Consumption and Device Operating Modes).</p> <p>Updated Layout Guidelines and Best Practices.</p> <p>Updated Electrical Specifications (Updated DC Electrical Characteristics (Updated DC Chip Level Specifications (Updated Note 6)), updated DC General Purpose I/O Specifications).</p> <p>Updated CapSense Specifications.</p> <p>Updated Ordering Information (Removed CapSense Block column).</p> <p>Updated Package Diagram.</p> <p>Added Appendix.</p> <p>Replaced all instances of sensor with button across the document.</p> <p>Updated in new template.</p> |
| *F | 3907113 | SEEE | 02/19/2013 | <p>Updated Device Features (Updated General Purpose Outputs).</p> <p>Updated Electrical Specifications (Updated DC Electrical Characteristics (Updated DC General Purpose I/O Specifications (Added Note 8 and referred the same note in parameter column in Table 9, Table 10, Table 11))).</p> <p>Updated Package Diagram: spec 001-09116 – Changed revision from *F to *G.</p> |

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- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «JONHON», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «FORSTAR».



JONHON

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



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