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Spec No: 001-48755

Spec Title: DESIGNING WITH CAPSENSE(R) EXPRESS(TM) 8-PIN SOIC DEVICE - AN48755

Replaced by: None

AN48755

Designing with CapSense® Express™ 8-pin SOIC Device

Author: Subbarao Lanka
Associated Project: No
Associated Part Family: CY8C20142
Software Version: PSoC® Designer™ 5.0 SP1
Related Application Notes: None

This application note evaluates the capacitive sensing performance of different CapSense® button shapes and sizes in the CY8C20142 8-pin SOIC device. It analyzes the maximum trace length supported by this device without using the C_{MOD} capacitor. The variation in SNR without C_{MOD} and improvement in SNR with C_{MOD} are also described.

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Introduction

The CY8C20142 8-pin SOIC device is based on the CSA (Successive Approximation) technique of capacitive sensing. This device does not use the external C_{MOD} capacitor that provides increased sensitivity. Therefore, there are limitations in the maximum trace length supported by the device.

When designing with capacitive sensors, board parameters such as shape and size of the capacitive sensor and trace length from the sensor to the sensing devices play an important role. This application note focuses on the optimal shape and size of buttons and sensors, and the maximum trace length supported by the 8-pin SOIC device. Layout parameters such as button GND spacing, GND fill, GND fill percentage, trace width, number of vias, via placements and diameter, and trace GND spacing are constant for all buttons. The effect of overlay thickness on performance is examined and the difference in SNR with and without the C_{MOD} capacitor is also illustrated.

Performance metrics for capacitive sensing is measured by calculating the Signal-to-Noise ratio (SNR). The sensitivity is measured with SNR measurements on an internal development board with buttons of various sizes and shapes as shown in Figure 1 to Figure 3.

Figure 1. Internal Development Board: Circular Buttons

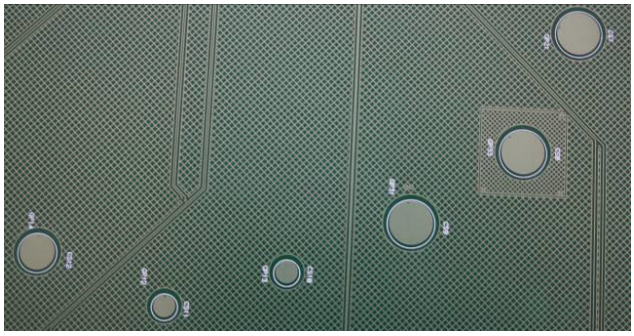


Figure 2. Internal Development Board: Rectangular Buttons with Curved Edges

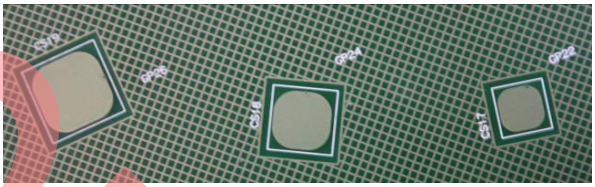


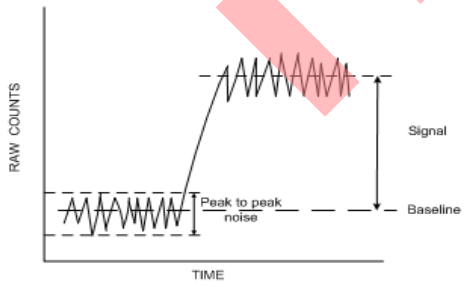
Figure 3. Internal Development Board: Irregular Button



Measuring SNR in a System

CapSense Noise is the peak-to-peak variation in the counts when no finger is present. CapSense Signal is the shift in average counts relative to the baseline when a finger is present. It is also known as the Difference Count. CapSense SNR is the ratio of CapSense Signal/CapSense Noise, usually expressed in dB, which is 20*log_10 (ratio).

Figure 4. SNR Measurement



SNR must be measured in the noise environment where CapSense is to be used. In other words, measure the system SNR under worst case noise conditions.

The first step in measuring SNR is to monitor the raw counts of each sensor. To do this, log data to a Text or Excel file and plot in a spreadsheet. It is also done with the Cypress FastChart GUI tool and Bridge Control Panel. Irrespective of the method, the raw count is observed for SNR measurement.

Another factor to consider is how the signal is produced. The worst case ON and OFF scenario is used when measuring SNR.

A good layout is essential for a high SNR. The selected overlay thickness or material type may limit SNR. After addressing layout issues, filtering techniques are used to minimize the noise component of SNR.

SNR Measurements on the Internal Development Board

The internal development board is designed to understand the limitations of the device with buttons of different shapes and sizes. Measurements are made to arrive at optimal button shapes and size for good SNR values with the 8-pin SOIC device. The maximum possible trace length to achieve a good SNR is determined for these buttons along with the variation in SNR with and without using C_{MOD}.

Performance of Buttons with Different Sizes

To understand the effect of button sizes, SNR measurements are made on a set of circular buttons (6 mm, 8 mm, and 10 mm) and a set of rectangular buttons with curved edges (6 mm x 6 mm and 8 mm x 8 mm) with profiles shown in Table 1.

Table 1. Profile of Buttons on Internal Development Board

CS#	Size	Shape	Trace Width
CS7	10 mm	Circular	8 mil
CS12	8 mm	Circular	8 mil
CS13	6 mm	Circular	8 mil
CS18	8 mm x 8 mm	Rectangular with Curved Edges	8 mil
CS17	6 mm x 6 mm	Rectangular with Curved Edges	8 mil

Figure 5 and Figure 6 show parts of the internal development board with rectangular buttons with curved edges and circular buttons of various sizes.

Figure 5. Rectangular Buttons with Curved Edges

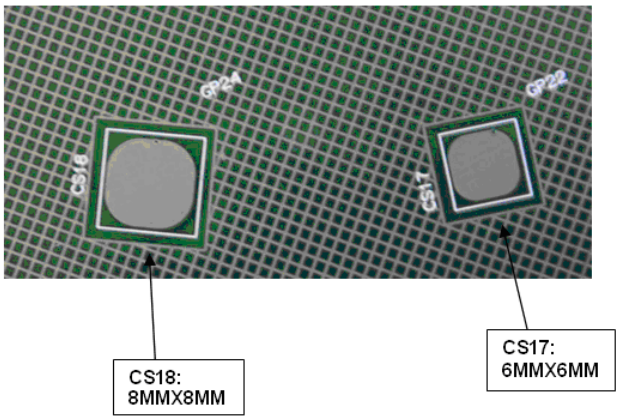
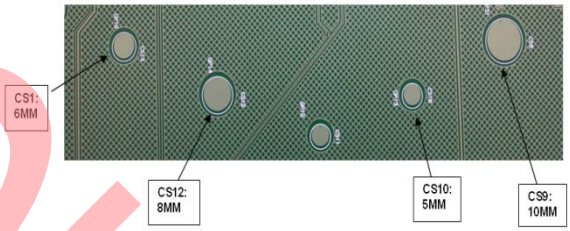


Figure 6. Circular Buttons



All the SNR measurements are made with overlays present on the buttons. Overlays of thickness 1.5 mm and 3 mm are used.

When measuring SNR, there is a variation in performance due to the size variation from 6 mm to 10 mm on circular buttons and from 6 mm x 6 mm to 8 mm x 8 mm on the rectangular button (with curved edges).

As shown in Table 2, circular buttons of 10 mm size and rectangular buttons (with curved edges) of size 8 mm x 8 mm are more sensitive than the buttons of smaller sizes.

Table 2. SNR for Buttons of Variable Sizes

Button	Shape	Trace Length	Size	SNR (1.5 mm Overlay)	SNR (3 mm Overlay)
CS13	Circular	10 cm	8 mm	5.6	2.5
CS12			8 mm	10.09	4.49
CS7			10 mm	25.032	17.5
CS17	Rectangular with Curved Edges	10 cm	6 mm x 6 mm	8.04	4.2
CS18			8 mm x 8 mm	27	8.63
CS14	Irregular	10 cm		24.36	6

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Effect of Overlays

SNR values are better with 1.5 mm overlay thickness compared to 3 mm overlay thickness.

With 1.5 mm overlay thickness, circular buttons of size 8 mm or more are recommended for good performance. To get a good SNR for trace length not greater than 10 cm, rectangular buttons with curved edges of sizes 6 mm x 6 mm or more are used.

When using 3 mm overlay thickness, circular button of 10 mm or more and rectangular buttons with curved edges of 8 mm x 8 mm or more are recommended for good SNR for various applications within 10 cm trace length.

The SNR measurements are analyzed for three main CapSense parameters affecting the signal measured when applying a finger on the button. These are clock (IMO), IDAC, and settling time. They are each varied between a minimum-average-maximum value and SNR is calculated for each case. Figure 7 through Figure 10 show the optimal configurations to achieve high SNR values.

1.5 mm Overlay

The optimal CapSense parameters configured for the circular and irregular buttons with 1.5 mm overlay are shown in Figure 7.

Figure 7. Configuration for Circular Buttons with 1.5 mm Overlay

Global Resources	Value
Power Setting [Vcc / SysClk freq	5.0V / 12MHz
CPU_Clock	SysClk/1
Sleep_Timer	512_Hz
SysClk Source	Internal 12_MHz
Trip Voltage [LVD (SMP)]	4.81V (5.00V)

CSA_1	
User Module Parameters	**Value**
FingerThreshold	100
NoiseThreshold	40
BaselineUpdateThreshold	100
SettlingTime	160
IDACSetting	10
ExternalCap	None
Hysteresis	10
Debounce	3
NegativeNoiseThreshold	20
LowBaselineReset	50
Sensors Autoreset	Disabled
High Level API	Enabled
Clock	IMO/2

The optimal CapSense parameters configured for rectangular buttons with curved edges are shown in Figure 8.

Figure 8. Configuration for Rectangular Buttons with 1.5 mm Overlay

Global Resources	Value
Power Setting [Vcc / SysClk freq	5.0V / 12MHz
CPU_Clock	SysClk/1
Sleep_Timer	512_Hz
SysClk Source	Internal 12_MHz
Trip Voltage [LVD (SMP)]	4.81V (5.00V)

CSA_1	
User Module Parameters	**Value**
FingerThreshold	80
NoiseThreshold	32
BaselineUpdateThreshold	200
SettlingTime	160
IDACSetting	10
ExternalCap	None
Hysteresis	10
Debounce	3
NegativeNoiseThreshold	20
LowBaselineReset	50
Sensors Autoreset	Disabled
High Level API	Enabled
Clock	IMO/2

3 mm Overlay

The optimal CapSense parameters configured for the circular and irregular buttons with 3 mm overlay are shown in Figure 9.

Figure 9. Configuration for Circular Buttons with 3 mm Overlay

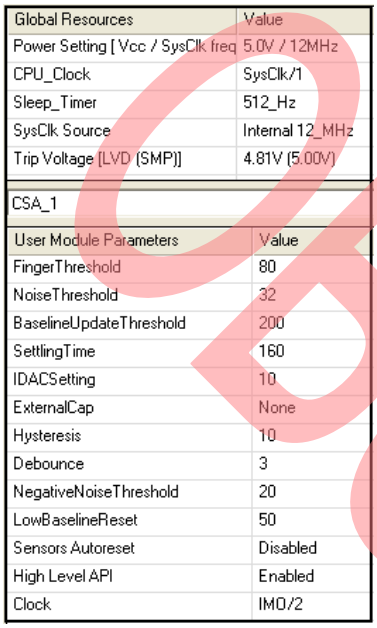
Global Resources	Value
Power Setting [Vcc / SysClk freq	5.0V / 12MHz
CPU_Clock	SysClk/1
Sleep_Timer	512_Hz
SysClk Source	Internal 12_MHz
Trip Voltage [LVD (SMP)]	4.81V (5.00V)

CSA_1	
User Module Parameters	**Value**
FingerThreshold	100
NoiseThreshold	40
BaselineUpdateThreshold	100
SettlingTime	160
IDACSetting	14
ExternalCap	None
Hysteresis	10
Debounce	3
NegativeNoiseThreshold	20
LowBaselineReset	50
Sensors Autoreset	Disabled
High Level API	Enabled
Clock	IMO/2

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The optimal CapSense parameters configured for rectangular buttons with curved edges with 3 mm overlay thickness are shown in Figure 10.

Figure 10. Configuration for Rectangular Buttons with 3 mm Overlay



Global Resources	Value
Power Setting [Vcc / SysClk freq	5.0V / 12MHz
CPU_Clock	SysClk/1
Sleep_Timer	512_Hz
SysClk Source	Internal 12_MHz
Trip Voltage [LVD (SMP)]	4.81V (5.00V)

CSA_1

User Module Parameters	Value
FingerThreshold	80
NoiseThreshold	32
BaselineUpdateThreshold	200
SettlingTime	160
IDACSetting	10
ExternalCap	None
Hysteresis	10
Debounce	3
NegativeNoiseThreshold	20
LowBaselineReset	50
Sensors Autoreset	Disabled
High Level API	Enabled
Clock	IMO/2

Performance of Buttons with Different Shapes

The maximum trace length supported between the CapSense button and the 8-pin SOIC device is analyzed for three different button shapes: circular, rectangular (with curved edges), and irregular.

The trace length between the button and the 8-pin SOIC device is increased to a point where the SNR dropped below a value of five (Table 1). These measurements are carried out with an overlay of 1.5 mm. For 3 mm overlay thickness, the trace length cannot be increased beyond 10 cm as shown in Table 2.

Table 3 shows the SNR values for a trace length of 20 cm for buttons of various shapes.

Table 3. SNR for Buttons of Different Shapes

Button	Shape	Size	Trace Length	SNR (1.5 mm Overlay)
CS7	Circular	10 mm	20 cm	9.64
CS18	Rectangular with Curved Edges	8 mm x 8 mm		12.5
CS14	Irregular			9.65

Circular buttons of size 10 mm or more and rectangular buttons (with curved edges) of size 8 mm x 8 mm or more are used to get a good SNR up to 20 cm with an overlay of up to1.5 mm thickness.

The rectangular button with curved edges gives the best SNR compared to the other two shapes.

Effect of Adding C_{MOD}

As described in the introduction paragraph of this application note, the CY8C20142 device does not support the addition of external C_{MOD} capacitor. However, it is beneficial to understand how CapSense performance is affected with the addition of an external C_{MOD} capacitor.

The variation in the SNR with C_{MOD} is seen in Table 4. The SNR for circular buttons increased by at least 5 units with a C_{MOD} of 1 nF. For rectangular buttons with curved edges and irregular shaped buttons, SNR increased with C_{MOD}.

Table 4. Variation in SNR with C_{MOD}

Button	Shape	Size	1.5 mm	C_{MOD}: 1 nF
CS13	Circular	6 mm	5.6	10.58
CS12		8 mm	10.09	16.21
CS7		10 mm	25.032	31
CS17	Rectangular with Curved Edges	6 mm	8.04	19
CS18		8 mm	27	32
CS14	Irregular		24.36	30.011

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Summary

Button size and shape and the overlay thickness affect variation in trace length between the button and CapSense device. Based on the SNR measurements with variable trace lengths and buttons of different sizes and shapes, the following is inferred to aid in designing with the 8-pin SOIC device without the C_{MOD} capacitor to achieve good SNR:

Optimal Button: Shape and Size	Shape	Size
Circular, > 8 mm	< 1.5 mm	< 20 cm
Rectangular with curved edges, > 6 mm x 6 mm	< 1.5 mm	< 20 cm
Circular, > 10 mm	< 3 mm	< 10 cm
Rectangular with curved edges, > 8 mm x 8 mm	< 3 mm	< 10 cm

As per the previous table, design using the CY8C20142 device puts an upper limit of 1.5 mm on the overlay thickness to be used (for a trace length of 20 cm and 8 mm circular button shape) in the end product. Customers who prefer to have thicker overlays in their end products should select CapSense Express devices with external CMOD support to enhance the upper limit on both overlay thickness and sensor trace length.

Rectangular buttons with curved edges offer slightly better SNR compared to circular buttons and buttons with irregular shapes for a given overlay thickness and trace length.

CapSense Express Documentation References

CY8C201xx Register Reference Guide.

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Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	2565752	NID	09/12/08	New application note.
*A	2903381	KPOL	04/01/10	Minor updates to the content.
*B	3704402	SLAN	08/06/2012	Updated Related Application Notes as “None” as all the application notes mentioned in the previous revision are obsolete. Updated Measuring SNR in a System (Removed all references of AN2403, AN2394, AN2292 as all these application notes are obsolete). Updated in new template.
*C	4622396	SSHH	01/13/2015	Replaced IIC USB Bridge to Bridge Control Panel Software Updated template
*D	5092581	PRIA	01/19/2016	Obsoleting the Application Note

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