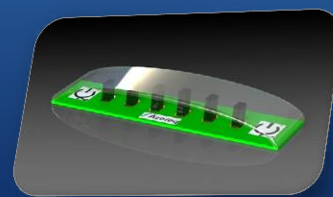
Azoteq

World Leader in Capacitive Proximity Sensing



How to Design Touch Electrodes for Non-Uniform Surfaces: Discrete Keys

By Alwyn Botha

Over the last few years, touch has become a standard input method for next-generation user interfaces for everyday applications, from white goods to smart phones and tablets. However, adding touch to modern designs, which are not flat or are made with more shapes and multiple parts, can be challenging.

In the first of a two-part series, this article shows how to accomplish touch detection on non-uniform surfaces, such as those with overlays of varying thickness and curved surfaces. The follow-up article will discuss the design and implementation of 2D track-pads on non-uniform surfaces.

Fill the air gap

When a rigid-sensor PCB is fitted inside a curved surface, an air gap is created between the overlay and the capacitive sensor.

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Content

Azoteq enables next generation user interfaces for users to interact naturally with products through capacitive proximity and touch

Azoteq's ProxSense® Portfolio

Controller	Description	Package	Channels	Self/Mutual	Interface	1k Price
IQS127D	1 Chan with Proximity, Touch, and ATI	TSOT23-6	1	Self	Direct	$0.27
IQS128	1 Chan DYCAL with intelligent hysteresis	TSOT23-6	1	Self	Direct	$0.29
IQS133	3 Chan with Touch and Proximity Outputs	MSOP-10	3	Self	Direct	$0.44
IQS213A	3 Chan SwipeSwitch™	MSOP-10	3	Self/Mutual	Direct/I²C	$0.31
IQS227A	1 Chan with Proximity, Touch, and ATI	TSOT23-6	1	Self	Direct	$0.27
IQS228A	1 Chan DYCAL with intelligent hysteresis	TSOT23-6	1	Self	Direct	$0.29
IQS229	1 Chan SAR detection device	DFN-10	1	Self/ Mutual	Direct/I²C	$0.30
IQS232	2 Chan with Direct Touch and Proximity Outputs	SO-8	2	Self	Direct	$0.30
IQS243	3 Chan with Touch and Proximity	MSOP-10	3	Self	I²C	$0.38
IQS253	3 Chan with Touch and Proximity	MSOP-10	3	Self/Mutual	I²C	$0.31
IQS316	16 Chan with Touch and Proximity	QFN32-5x5	16	Self	I²C/SPI	$0.52
IQS333	9 Chan Touch and Proximity with Slider	QFN32-5x5	9	Self/Mutual	I²C	$0.36
IQS360	3 x4 Chan Trackpad Controller with Snap	QFN32-5x5	12	Mutual	I²C	$0.43
IQS525	5x5 Chan Trackpad/Touchscreen Controller	QFN28-4x4	25	Mutual	I²C	$0.89
IQS550	10x15 Chan Trackpad/Touchscreen Controller	QFN48-7x7	150	Mutual	I²C	$1.61
IQS904A	1 Chan Touch & Proximity AC Dimmer Controller	TSOT23-6	1	Self	Custom	$0.27
IQS904D	1 Chan Touch & Proximity DC Dimmer Controller	TSOT23-6	1	Self	Custom	$0.27
IQS924	2 Chan Touch & Proximity Dimmer Controller	SOIC-14	2	Self/Mutual	Direct	$0.38

Functions of ProxSense®

There are several functions that ProxSense® can provide for you. Some examples of these functions are:

- Proximity Wake-Up
- Proximity, Touch, Click
- SAR Detection
- Gestures
- Find-in-the-Dark
- Waterproof switch
- Track-pad
- Touchscreen

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Air gaps between the PCB and the overlay material reduce the performance of capacitive touch sensors. The reduction in sensitivity is due to the fact that air has a much lower dielectric constant than most overlay materials.

A list of commonly used overlay materials with their dielectric constants compared to air is shown in Table 1.

Material	Permittivity (ε_r)	Breakdown voltage (V/mm) (approx.)
Air	1	1,180
Glass (standard)	7.6 – 8.0	7,800
Plexiglass	2.8	17,700
Mylar	3	295,200
FR4	4.7	27,500
Nylon	3.2	16,000

Table 1: Material Properties

We will discuss two main options to remove the air gap: spring contacts and flexible PCBs.

Use of spring contacts

Springs and conductive rubber or carbon contacts work well to remove the air gaps between the PCB and the overlay.

In applications where it is not possible to fix the electrode PCB to the overlay, conductive rubber or carbon contacts work well to remove small air gaps, whereas larger air gaps can be removed with springs.

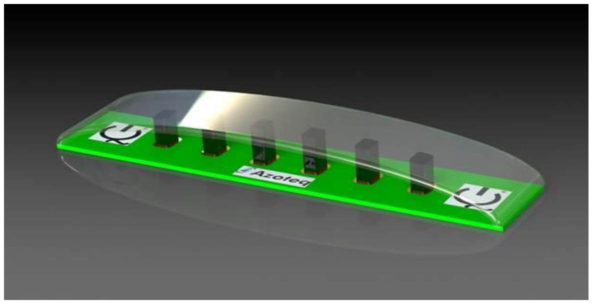

Figure 1: Conductive rubber can be used to remove small air gaps between the overlay and the PCB.

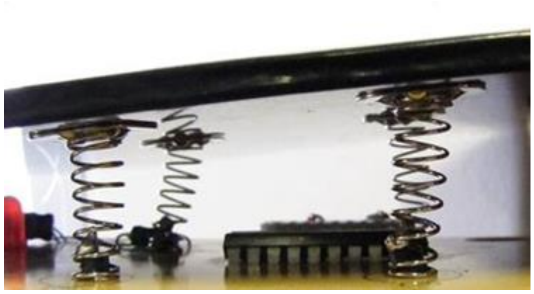

Figure 2: Simple helical springs soldered to a PCB pad can remove larger air gaps between the sense electrode and the overlay.

The disadvantage of using springs to connect the electrode to the overlay is that the surface area of the touch electrode is limited to the size of the spring used. According to the parallel plate equation shown in Equation 1, small surface areas are less sensitive. This limits the possible thickness of the overlay or the relative permittivity of the overlay for a set thickness.

To improve sensitivity, conductive tape (metal foil) can be used. The tape can be stuck onto the overlay to give a larger surface area when the spring presses up against it. In applications where the overlay is required to be transparent (for example to accommodate backlighting) transparent conductive films such as ITO (indium-doped tin oxide) could be considered. Alternatively a metal plate could be used at the top of the spring, as commonly used in battery terminals.

$$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

Equation 1

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Equation 1 shows the parallel plate capacitor equation where A is the area of the pad, ε_0 is the permittivity of the air, ε_r is the relative permittivity of the overlay material and d is the thickness of the overlay.

Springs could also be connected to a surface of conductive paint. Conductive paint could be used around the touch key area to provide a larger surface area (A) to increase the proximity detection distance. Conductive paint can be applied to any non-uniform surface.

Molding pillars in the overlay

The latest generation of touch controllers from Azoteq provides another alternative for removing air-gaps. New controllers, such as IQS333 and IQS360, allow the designer to remove any air gaps with non-conductive materials that are less expensive. An example would be adding pillars at the touch positions when creating a molded part as overlay, as shown in Figure 3.

Figure 3: Molded overlay to form pillars over the electrodes, thus removing air gaps.

Flexible PCBs

In some applications, the spacing of the touch keys could require the sense electrodes to be placed close together. In these applications, spring or rubber contacts are not the best option. The designer might require the more directional approach of projected capacitive sensing. Some applications require shielding between keys, which requires ground to be added between the self-capacitive electrodes to reduce the risk of multi-touching.

In these types of applications, the designer can remove the air gap by matching the curved surface. This is accomplished by fixing a flexible PCB (FPC) to the curved surface with double-sided adhesive tape. The designer may choose to create a complete FPC module, which includes the touch controller as well as the sense electrodes. Alternatively, only the sense electrodes could be placed on the FPC, which can connect to the controller through a cable connector or FPC tail.

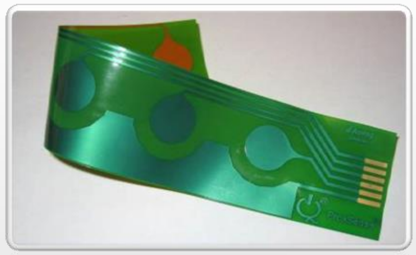

Figure 4

FPC with self-capacitive touch electrodes and FPC tail.

Figure 5

Illustration of a 3D curved surface.

ProxSense® Capacitive Proximity and Touch Controllers

Azoteq's ProxSense® portfolio of Touch and Proximity controllers offers the highest sensitivity and signal to noise ratio integrated into a low cost package. Azoteq controllers offer proximity and touch on all channels, in self and mutual capacitance configurations.

Features

- 1 to 150 Channels
- Sliders and scroll wheels
- Automatic tuning to optimum sensitivity
- Fast I2C or discrete interface
- Event Mode or streaming modes
- Supply Voltage: 1.8V to 5.5V
- Low Power Operation <5uA

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