World Leader in Capacitive Proximity Sensing

Capacitive sensing in battery-powered devices--Design considerations

By Riaan du Toit

Mobile devices such as tablets and cellphones require proximity sensors for Specific Absorption Ratio (SAR) qualification and on-ear detection. Capacitive sensing may be used to meet both of these needs. Self-capacitance technology is popular for proximity sensing in mobile devices.

The sensing electrode size, shape, position and closeness to ground all affect the proximity range. This article focuses on the effective use of the capacitive sensor electrode reference (battery ground) and presents another variable reference introduced by the user (earth).

The article will also address design techniques to meet SAR certification.

Overview of capacitive proximity sensing

Capacitive sensing is one of the few cost-effective technologies that pass the SAR qualification tests. Capacitive sensing addresses all the limitations of other sensor technologies.

Continued on Page 3

Content

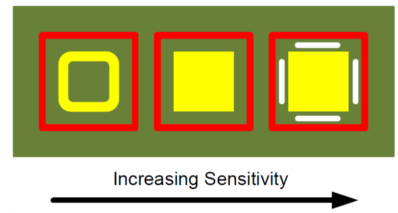
Azoteq enables next generation user interfaces for users to interact naturally with products through capacitive proximity and touch

Electrode Shapes for Thicker Overlays for Projected Capacitance

Although capacitive touch sensors from Azoteq are fully customizable for sensitivity settings on each channel, as well as adjustable detection thresholds for set sensitivity selections, the designer could save time in fine tuning the sensitivity of each electrode by compensating for variations in the thickness of the overlay material in the electrode design.

For projected capacitance, bigger gaps between the TX and RX electrodes will give more sensitivity (but reduce stability), or using thicker receivers in the electrode will allow for thicker overlays (but reduce conductive noise immunity).

The figure to the right shows different electrode variations of the same design (for projected capacitive sensing) for different overlay thicknesses (in order of increasing sensitivity).



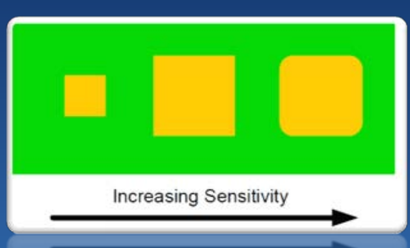
Projected Button Layouts

These layouts are in order of increasing sensitivity. Red represents the TX electrodes, yellow represents the RR electrodes and white represents the PCB cut-outs. The dimensions of all three buttons illustrated are the same.

For more information, email info@azoteq.com.

Electrode Shapes for Thicker Overlays for Self-Capacitance

For self-capacitive sensing, bigger electrodes will give more sensitivity, and avoiding sharp corners that form concentrations in field lines will allow for thicker overlays. The figure below shows different electrode variations of the same design (for self-capacitive sensing) for different overlay thicknesses (in order of increasing sensitivity).



Self-capacitive buttons illustrated in order of increasing sensitivity by increasing the size of the electrode and removing sharp edges that form concentrations in field lines.

Page 1 Continued

It is important to note some key points when implementing a capacitive sensor in a complex and compact design that requires optimal performance:

Dependence on battery ground: All sensor measurements are taken in relation to battery ground (device ground). Variance between human body ground (well coupled to earth) and device ground will affect the performance. The illustration below shows these potential variables.

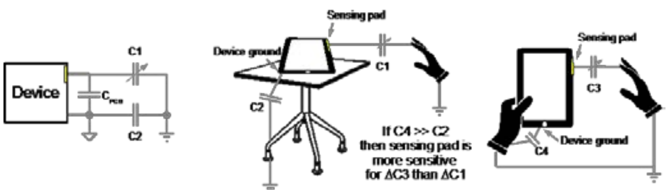


Figure 1: Circuit element description showing device ground effect on sensitivity

Extreme sensitivity: The graph below shows the theoretical values of a parallel plate capacitor. A similar case will be true for a human (infinite ground plane) approaching a capacitive sensor (charged electrode). Keeping this type of sensitivity in mind (low femto-Farad deltas per mm) it is easier to understand that mechanical instability and typical device placement may also trigger the sensor. Mechanical instability refers to movement in the micrometer range of the flexible printed circuit (FPC) or device cover in relation to a battery itself, or to another large ground structure in the device.

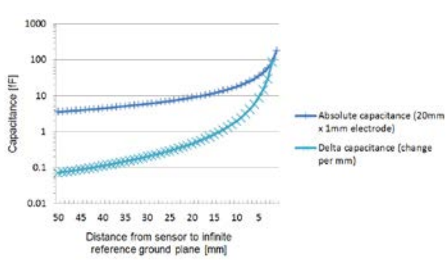


Figure 2: Capacitance estimation of a small 1 mm x 20 mm electrode at varying distance from the phantom body (ground plane)

Optimize electrode size

Electrode design (sizing and placement) cannot be done separate from ground reference considerations. This is because an electrostatic field is formed between the electrode and ground reference in the same way as a field is formed in a parallel plate capacitor. See the illustrations in Figure 3 below to see how the parallel plate capacitor model may be translated into a device.

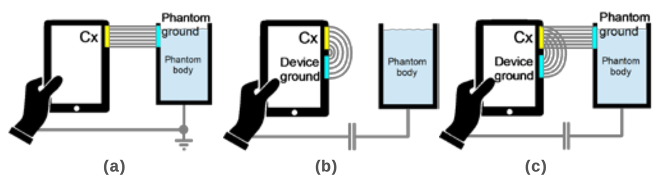


Figure 3: (a) An example of how the parallel plate capacitor model may be translated into device testing, (b) an example of typical coupling to the device ground (open folded capacitor), (c) a combination view, emphasizing that the two effects together determine the trigger distance

If the trigger plane (phantom body, hand, etc.) is larger than the electrode itself, a good "rule of thumb" for the trigger distance is:

Trigger distance 1 ≈ length of electrode (with 1 mm width)
OR
Trigger distance 2 ≈ distance between electrode and device ground
The smallest of these two will dominate

In most cases, increasing the electrode width will have a positive effect on the trigger distance. When the width is extended towards the device ground so that "trigger distance 2" dominates, then the intended effect of the larger electrode will be lost.

Full Article Available on EDN.

Specific Absorption Rate for Mobile Phones

SAR, or Specific Absorption Rate, is the amount of radiation (in this case RF radiation) a body absorbs when using a wireless device such as a mobile phone.

Current Regulations

The current FCC regulations require mobile phones to have a SAR level below 1.6 watts per kilogram (W/kg) taken over the volume that contains a mass of 1 gram of tissue that absorbs the most signal.

These regulations were put into place with the assumption that the main source of radiation exposure would be during phone calls and that afterwards, the phone would be carried in a holster 2.5cm away from the body. Times have changed since these regulations were put into place and now more and more people use smart phones and carry them around in their pocket.

Since the regulations did not account for this kind of usage, the user higher radiation exposure is when the phone is carried in their pocket. While in a user's pocket, the mobile phone constantly checks for email, downloads software updates and updates social networks.

Regulation Discussion for Mobile Phones

Currently, the FCC has opened up a discussion to update the RF Exposure Policies. To keep track of the discussion, please see the following steps:

1) To access the filings, go to http://apps.fcc.gov/ecfs/

2) Select "Search for Filings"

3) Enter "Proceeding Number" 13-84 for the NOI or 03-137 for the R&O and FNPRM.

The main RF Item document is available at http://www.fcc.gov/document/fcc-review-rf-exposure-policies

Use of Mobile Phones

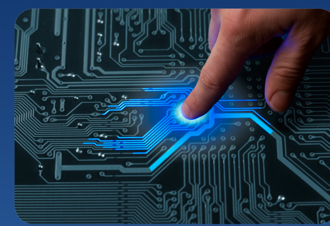
With more smartphones on the market, the highest source of RF radiation exposure is while it is in a user's pocket

For more information, email info@azoteq.com

Communication Guidelines

To support designers and programmers to effortlessly develop firmware, Azoteq provides communication guidelines for several of our devices.

While register specific information is available within the datasheet, these guidelines help designers and programmers with managing the devices' I²C slave. These guidelines also give a good platform from which to develop application specific firmware.



Full Application Note is available here!

Sales

Azoteq International
Jean Viljoen
+27 21 863 0033
jean.viljoen@azoteq.com

Azoteq USA
Kobus Marneweck
+1 512 538 1995
kobusm@azoteq.com

Azoteq Asia
Lina Yu
+86 (138) 2696 0845
linayu@azoteq.com.cn

Distributors

Worldwide
Mouser Electronics
+1 800 346 6873
Sales@mouser.com

Worldwide
Future Electronics
+1 514 694 7710

Taiwan
Holy Stone Enterprise Co. Ltd
Terry Chiang
+886 2 2659 6722 ext. 302
terrychiang@holystone.com.tw

China
Infortech
Summer Yin
+86 21 51087875 ext. 355
summer_yin@infortech.net.cn

South East Asia
Locus Marketing Pte. Ltd
Sam Liew
+65 6299 7308
+65 6292 5848
samliew@locus.com.sg

France and China
Seltech
+33 (0) 1 48 92 90 02
+86 25 83 45 54 33
Europe@seltech-international.com
Asia@seltech-international.com

China
Lierda Technologies
+86 571 8880 0000/8990 8135
+86 755 8378 0888
hangzhou@lierda.com
shenzhen@lierda.com

Japan
Nomura Jimusho, Inc.
+81 3 3502 1466
yamashita@nomjim.co.jp

Distributors

Europe – UK, Ireland
IO Components LTD
+44 (0)1202 440422
paulb@io-components.com

South Korea
SEMPOST
+82 2 2688 1588
jason@insem.co.kr

Representatives

USA- Southern California
O'Donnell South
+1 310 781 2255
sales@odas.com

USA- GA, NC, SC, TN, MS, AL
Quantum Marketing, Inc.
+1 310 781 2255
jeannette.ayerbe@qmirep.com

USA- NY, NJ, PA, DE, MD, VA
Analectro
+1 856 795 6676
sales@analectro.com

USA- Northern California
O'Donnell Associates North
+1 408 456 2950
wepich@odonnell.com

USA- TX, LA
Logic 1 Sales
+1 512 656 4686
pat@logic1.us

USA- MA, NH, VT, ME, CT, RI
Coakley, Boyd & Abbett
+1 508 820 0800
rwalsh@cbane.com

USA – IL, WI
Horizon Technical Sales
+1 630 852 2500
lward@horizontechsales.com

Central Europe
ActiveRep GmbH
+49 (0) 812 2227 9270
+49 (0) 171 3098 721
brendon.hutton@activerep.com

India
Enecon Technologies
+919900212558
shivu@enecontechnologies.com