AZD058 Tablet Computer Proximity Sensors - Application Note

Version 1.0

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1 Introduction

It is understood that SAR (Specific Absorption Rate) regulations force mobile device designers to limit RF power in the presence of a human body. Antenna power output is to be optimised for best performance otherwise.

One of the best methods of detecting the presence of a human body is capacitive sensing. However, capacitive sensing results are also affected by non-human materials such as wood, glass and metal. It would be beneficial to distinguish between the human body and non-human objects in order to implement SAR regulations while maintaining optimal wireless connectivity and performance.

This document addresses the following:

- Distinction between human body and non-human objects
- Choice of technology: DYCAL™ or standard touch triggering
- Choice of capacitive sensing method: Projected- or self- capacitance
- Thickness and type of overlay
- The effect of aftermarket tablet computer covers
- Start-up environment versus sensing accuracy
- Demonstration tablet computer results
- Selection of device for specific application
- Conclusion

Capacitive proximity sensing in tablet computers has many advantages which include:

- Lower power consumption than infrared solutions
- No aperture required
- Not affected by ambient light conditions
- Small real estate required for sensor
- Low cost

2 Distinction between human body and non-human objects

It is difficult to distinguish between human and non-human interaction using capacitive sensing. As seen below, the effect is almost identical when placing the sensor on a sheet of metal and then on a persons' lap.

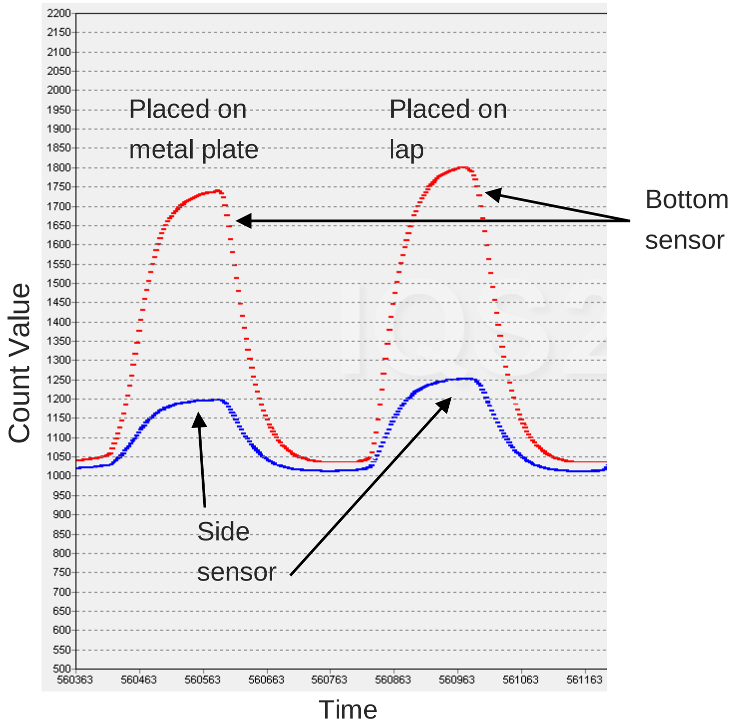


Figure 2.1 Capacitive sensor counts for human and non-human interaction

It should be clear from this graph that the capacitive characteristic of human and non-human objects may be identical.

Metal (high conductivity) effectively unites the electrodes and enlarges the sense area. A touch on the metal plate would reflect on all channels.

Glass (high permittivity) has the effect pulling field lines inward (especially in projected capacitive sensing), decreasing sensitivity. In certain environments the glass object may cause an improved path to earth, thus pulling field lines away from the projected sensing receiver (in the same way as a human touch would).

A solution using a single sensor to distinguish between human and non-human interaction would be very difficult if not impossible.

In order to distinguish, the use of multiple sensors is proposed. Using such approach it is possible to distinguish between human interaction and placement on a flat non-human object which may produce capacitive effects like a human touch.

As an ideal solution the following setup is proposed as shown in Figure 2.2:

- 4 sensors at the bottom of the device (1,2,3,4) and
- 2 sensors on the sides (5,6), or wherever the RF antennas are.

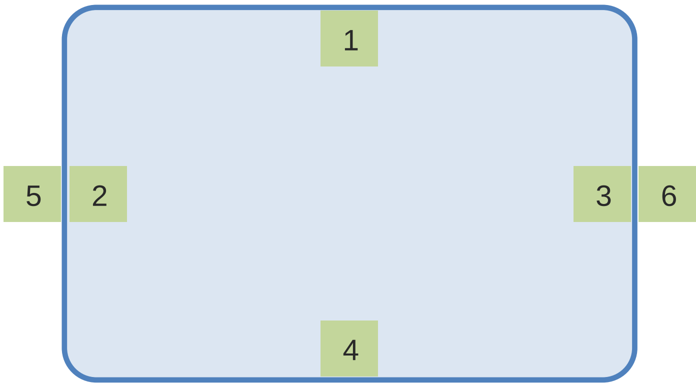


Figure 2.2 Tablet sensor setup for a 6 sensor solution

A human will find it very difficult to trigger all 4 bottom sensors at the same time for an extended period. When placing the device on a flat surface, either all will be triggered or none, both resulting in a state where wireless communications can be driven optimally. Two sensors on the sides will ensure detection close to the antennas.

Various other configurations are possible with the same type of results. For example (shown in Figure 2.3), by using only 3 sensors you may use:

- one sensor on the back of the device (1) and
- two sensors (2 & 3, one on each side of the tablet computer) to each detect
  - proximity towards the sides (hand detection) and
  - bottom (hand and flat surface detection)

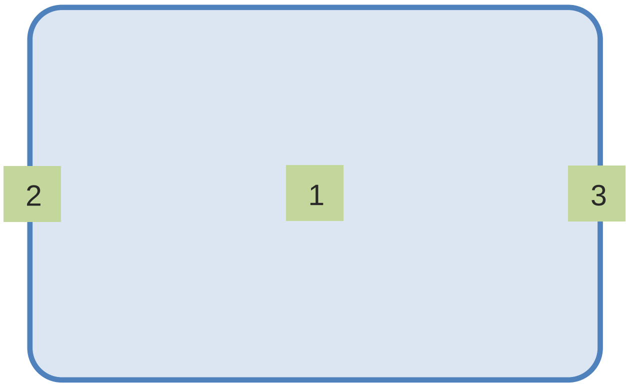


Figure 2.3 Tablet sensor setup for a 3 sensor solution

These solutions can be realized by using multi-channel ICs or single channel ICs.

This approach to proximity detection in tablet computers could lead to effective adherence to SAR regulations while keeping the optimal signal strength for effective wireless communications.

3 Choice of technology: DYCAL™ or Standard touch triggering

3.1 DYCAL™

DYCAL™ is a patented implementation of dynamic threshold adjustment that calibrates according to environmental drift during periods of activation or at release events. Touch events trigger a DYCAL™ event and touch releases exit the DYCAL™ event. This occurs in such a way that the device will:

- Enter a DYCAL™ event with a touch threshold crossing in the right direction (direction differs between projected- and self-capacitance technology).
- The device will exit the DYCAL™ event with a release threshold crossing in the opposite direction
- Both touch and release thresholds are calculated using the long-term average (LTA) values as reference

This enables the following:

- A device may be taken from one environment to another and intelligently adapt via a release event
- By keeping track of touch and release events, the device will not adapt to the entity that caused the DYCAL™ event. In other words, a person using a tablet would cause a DYCAL™ event by picking up the tablet. It can now be used and carried around while the device is still aware of the initial entrance into the touch event. The device will not re-calibrate and nullify the touch by including it in its calibration (as will occur with non-DYCAL™ devices). Only when the tablet is released and placed in a different environment, will it re-calibrate and adapt to this environment.
- Touch intensity variation is allowed according to the release threshold and initial touch intensity. This allows the user of a device variance in the touch strength while still remaining in a DYCAL™ event. In other words, small variations of movement in hand or on lap can be compensated for.

3.2 Standard Touch Triggering

Using standard touch triggering involves the use of an adjustable threshold (specific level of difference between the sensor counts and long term average counts). Entering and exiting touch conditions occurs around a specific threshold. If the Automatic Tuning Implementation (ATI) is enabled, a very long touch condition will be lost and integrated through the recalibration as part of the environment. Standard touch triggering is not ideal for mobile applications where touch conditions will be triggered for long periods of time and the designer wants to make use of the automated tuning algorithms. Making use of these algorithms would simplify the software design.

4 Choice of capacitive sensing method: Projected- (Mutual) or self- capacitance

Both self- and projected- capacitance technology could be used for the tablet application. Generally projected tends to perform better in battery operated products where capacitive differences are measured between two electrodes and not from a single electrode to earth (as with self-capacitance implementation). The effect of a close-by earth reference is less severe in projected capacitance solutions.

5 Thickness and type of overlay

For demonstration purposes 3mm thick PMMA (Perspex) layers were used on the bottom and side of the tablet representation. The sensing electrodes occupy a rectangular area of 12mm x 8mm each. The ProxSense® sensitivity is highly adjustable and a variety of electrode sizes and overlay materials are possible.

6 The effect of aftermarket covers

It is a popular trend to fit a tablet computer with a protective cover or sleeve. The effect of a cover on emitted power levels is a concern. This is because the cover may trigger the proximity sensor, and thus reduce the RF power unnecessarily. It is ideal to emit optimal power with any sleeve or cover fitted and only lower power levels on user detection close to the RF antenna.

With this in mind, tablet cover and sleeve designers are limited in accommodating various types of sensors in order to ensure optimal RF emissions. It often happens that a cover is purchased that will cause the tablet computer to constantly operate with lower RF output power. This could lead to a degraded user impression about the tablet itself.

Capacitive sensing solutions have the advantage over infra-red solutions that non-transparent obstacles are much less of a problem. The detection of a tablet computer cover can also be done through the use of capacitive sensing technology. In this way a tablet computer can compensate for covers that are designed according to a certain specification.

7 Start-up environment versus sensing accuracy

In a power-up state, an automatic tuning implementation (ATI) may run if enabled. ATI may also run on channels which do not have an active DYCAL™ event.

ATI would occur taking the device from an environment where capacitive field lines are tightly coupled, to an environment where field lines tend to be coupled loosely (eg. taking the tablet from a metal surface to air). This would happen as the tablet is moved and is advantageous to its sensing responsiveness.

A possible SAR regulation failure condition could occur when a device is held in hand at device power up. At power up the capacitive sensing ICs could calibrate automatically. If this is done automatically, the device will include the effect caused by human interaction in the calibration. By using an I^2C-based device, automatic calibration may be disabled and custom calibration values may be written to solve this issue.

8 Demo tablet computer results

A demonstration model was built where a single IQS253 was used. The ideal solution would have two of these devices fitted. The antennas for the demo are indicated in Figure 8.1 and are fitted on the left bottom (Channel 0), left side (Channel 1, vertical) and middle bottom(Channel 2).

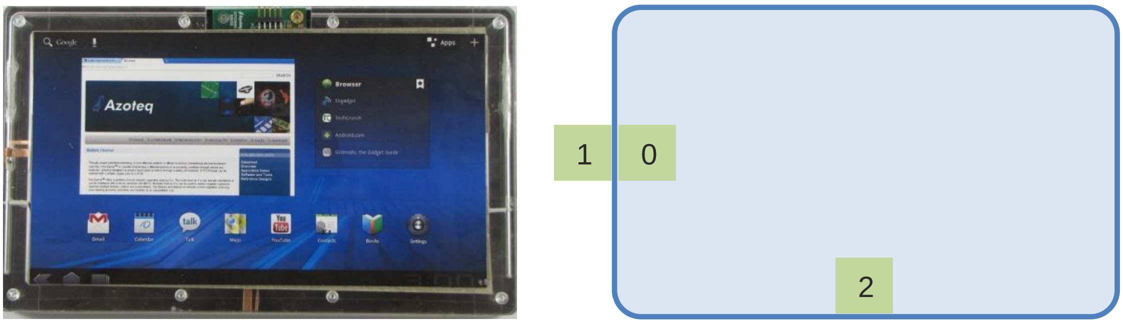


Figure 8.1 Demo tablet computer sensor placement

A wireless communication device was used to prove the concept for a battery operated handheld device. Having a reference to earth through a bench power supply has an effect on the test results. By using a battery and wireless link to the computer, more accurate results can be obtained.

The 'screen' of the tablet was modelled with conductive tape connected to the battery supply negative.

This setup can be seen in Figure 8.2 along with an example in Figure 8.3 of how to interpret the results:

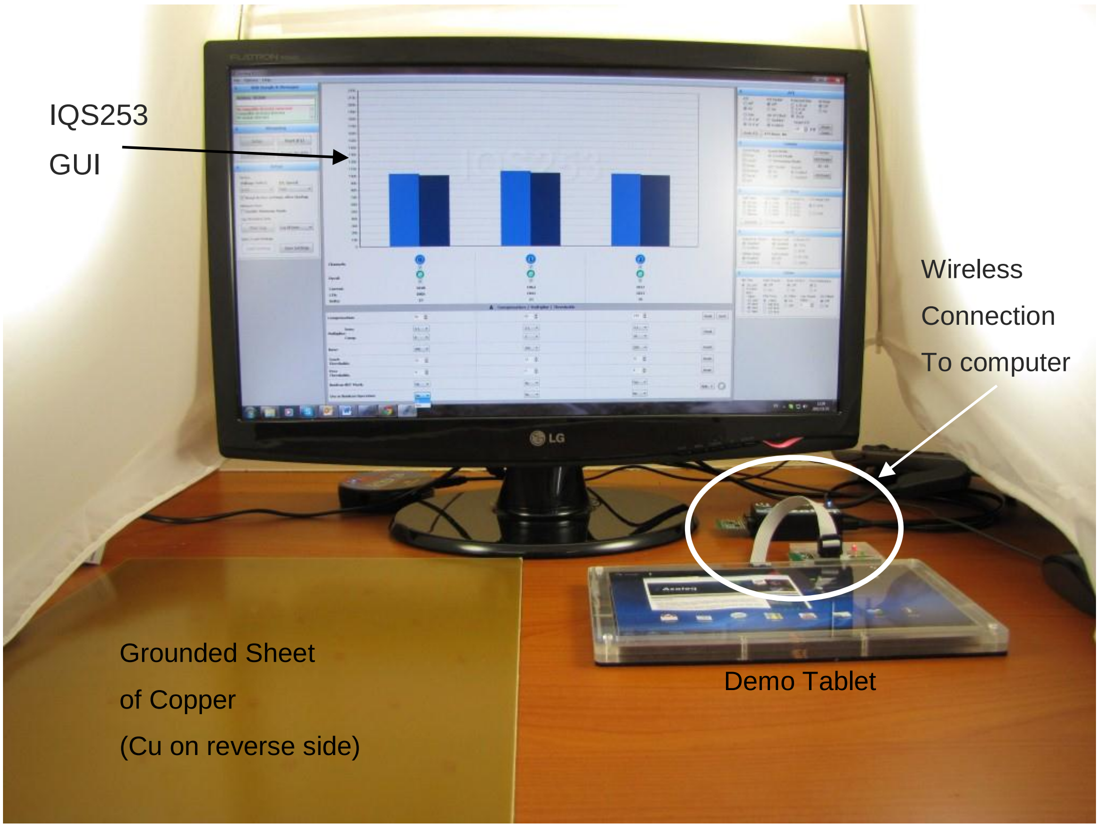
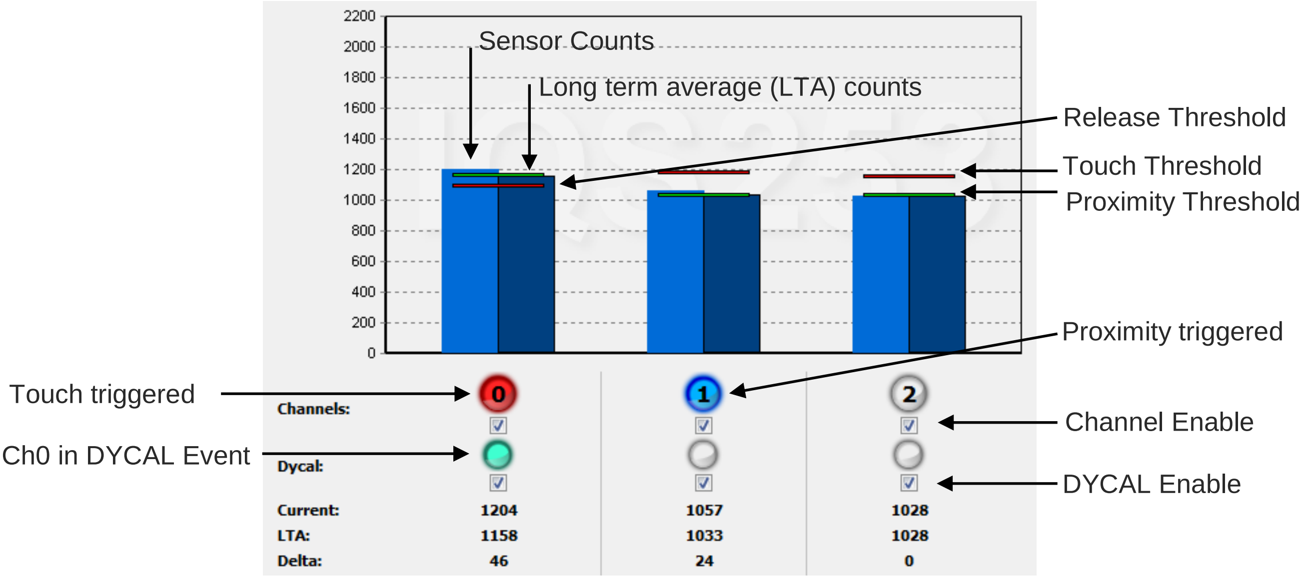


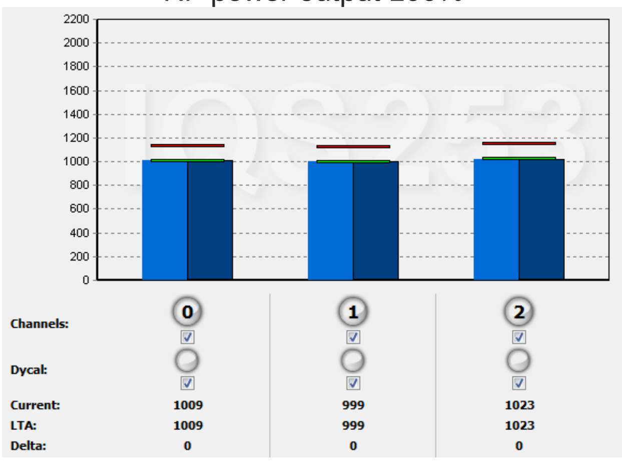
Figure 8.2 Demo tablet proximity sensing evaluation setup



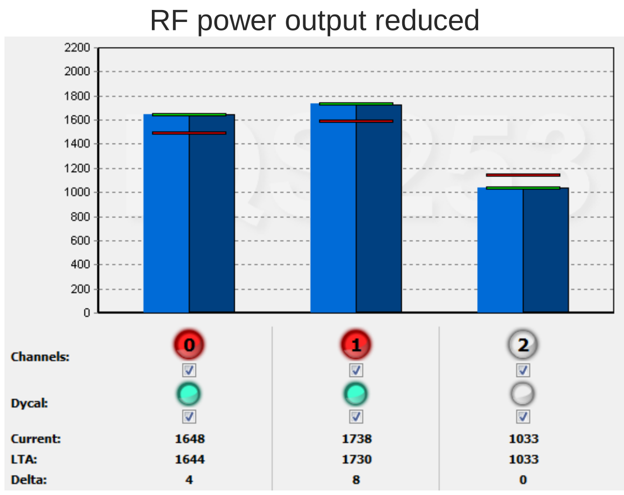
Channel 0	Channel 1	Channel 2
Bottom Left Sensor (lap sensor)	Left Side Sensor (hand sensor)	Middle bottom sensor (flat surface sensor)

Figure 8.3 GUI screen guide

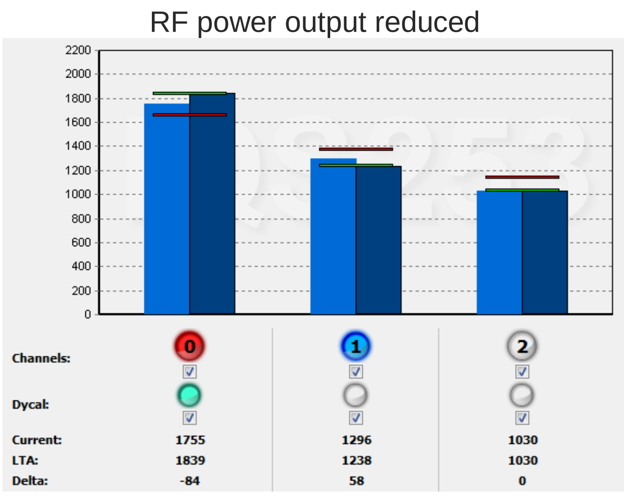
The following table shows results for a device that is calibrated in mid-air. Various general use examples are given to show how the IQS253 may be used to detect human and non-human touch triggering.

Startup in Air:	RF power output 100%
	

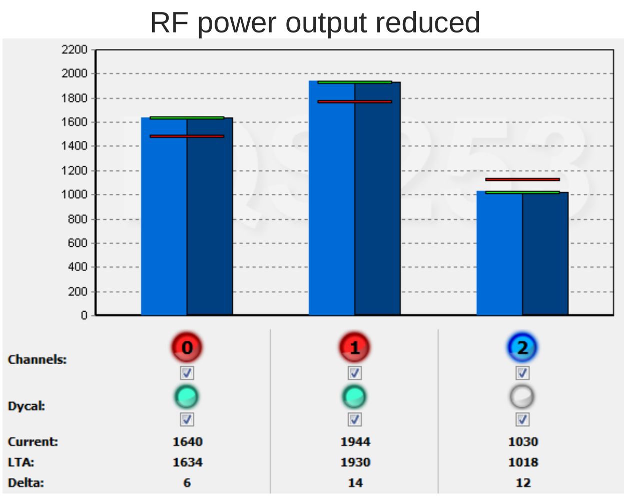
In hand:



On lap (position 1):

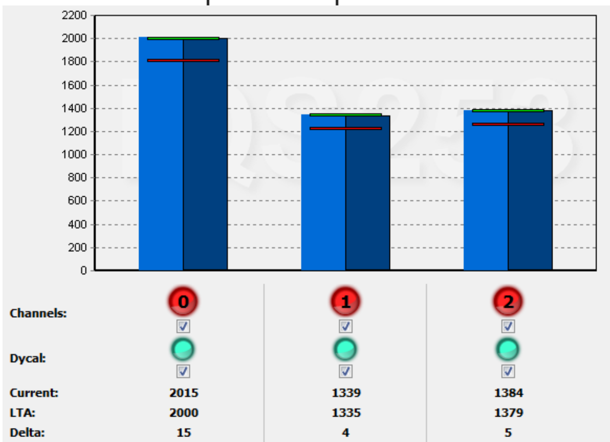


On lap (position 2):



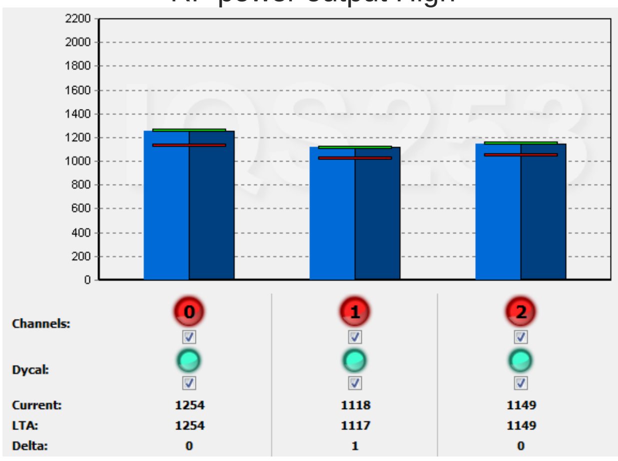
On sheet of earthed metal:

RF power output 100%



On 20mm thick Glass:

RF power output High



9 Selection of Device for specific application

Azoteq offers various solutions and a few are suitable for this application. They are:

- IQS253, a 3-channel DYCAL™ device, I²C compatible, projected- or self- capacitance.
- IQS128, a 1-channel standalone DYCAL™ self-capacitance device
- IQS252, a 2-channel standalone DYCAL™ projected capacitance device (to be release Q1, 2012)

The IQS253 is recommended for the following reasons:

- Possibility to meet all SAR requirements while optimizing radiated power
- Flexibility offered through the I²C communications (device specific calibration for power-up, complete control over various parameters)
- Lower component count while offering multiple channels

The other standalone options may offer an acceptable but simplified solution.

10 Conclusion

As a proven concealed solution (as opposed to optical solutions), capacitive sensing is recommended as a solution to meet SAR requirements.

The tracking of touch and release events with DYCAL™–based solutions are ideal for hand-held device applications.

The use of projected capacitance solutions is recommended for battery powered devices. Surface capacitance solutions have a dependence on an earth reference which widely varies in hand-held applications.

A multi-channel solution (ideally six channels) is proposed for the distinction between human and non-human interaction.

Device power up from an off condition is a risk area for failing SAR regulations. An I²C device (like the proposed IQS253) offers the ability and flexibility to switch on with calibrated values for detecting human interaction on start-up.

The tablet demo results should clearly show the possibility to power down RF emitting devices when only hand or lap sensors are triggered, while optimally powering the devices when all sensors are triggered. Triggering all sensors at once should be very difficult and unnatural for a person to do.

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