Application Note: AZD056
IQ Switch® - ProxSense® Series
The IQS243 family SNR Overview

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1 Overview

1.1 IQS243 family – Features

The IQS243 family ProxSense® devices are fully integrated capacitive touch and proximity sensors with unsurpassed sensitivity and automatic tuning to the sense antenna. These devices present cost effective implementation and minimal design constraints, additionally providing full controllability through an I^2C communication interface.

Main Features

- Individual channel Touch and Proximity
- I^2C compatible data output
- ATI – Antenna Tuning Implementation
- Supply Voltage: 1.8V to 3.6V
- Sub 3uA* current consumption
- Automatic Drift compensation

*Current consumption dependant on device configuration and selected power mode.

IQS243 and other **ProxSense®** information available from: **www.azoteq.com**

1.2 Capacitive touch SNR (Signal-to-Noise Ratio)

The **signal-to-noise ratio** (**SNR**) in capacitive touch systems can be defined as the ratio between the "**increase/decrease in counts due to a touch activity**" and the "**RMS (root-mean-square) value of noise present in the system**", taken over a certain number of samples.

In general, the basic SNR for a specific application may depend on the actual/physical device setup and factors like system sensitivity and sampling frequency can influence the relevant SNR measurement.

In order to eliminate the effects of human error introduced into the characterization of the device's SNR measurements, the touch activity can be emulated by coupling a passive load (external capacitor) to the sense antenna. For emulating a moderate to strong touch activity, a 1-2 pF load can be applied.

2 IQS243 family SNR Characteristics

2.1 SNR calculation

For calculation of the typical SNR of ProxSense® devices during a touch activity, the following equation can be implemented:

$$\boldsymbol{SNR_{dB} = 20log\left(\frac{\Delta_{touch}}{Noise_{RMS}}\right)}$$

where

$$\Delta_{touch} = \boldsymbol{Signal\ AVG_{untouched} - Signal\ AVG_{touched}}$$

- $\boldsymbol{Signal\ AVG} = Numeric\ average\ of\ 1000\ data\ pionts,$ $typically\ taken\ evenly\ spaced\ with\ a\ sampling\ period\ of\ 27ms.$

The RMS noise, **during a touch activity**, is thus calculated by:

$$\boldsymbol{Noise_{RMS}} = \sqrt{\frac{\sum_{n=0}^{n=999}(Signal[n] - Signal\ AVG_{touched})^2}{1000}}$$

- $\boldsymbol{Noise_{RMS}} = Root\text{-}mean\text{-}square\ of\ 1000\ data\ points,$ $typically\ taken\ evenly\ spaced\ with\ a\ sampling\ period\ of\ 27ms,$ $using\ the\ Signal\ AVG_{touched}\ as\ a\ baseline\ figure.$

2.2 SNR Measurement results

The measurement results portrayed in this section were obtained with the IQS243 capacitive sensor IC, configured in the test setup described in Section 3. The IQS243 device features a surface capacitance, 3 channel touch and proximity sensor and employs an advanced event mode / normal I^2C communication interface.

For performing the SNR measurements, a single channel on the IQS243 device was enabled, and the automatic ATI (antenna tuning implementation) functionality was enabled, with the device connected to an Azoteq configuration tool (CT200 or CT220).

Table 2.1 presents the test data and calculated SNR figures for the IQS243 device. These SNR measurements were performed for both a 2 pF passive load and a moderately strong human touch (with a single index finger), through a typical overlay material.

Table 2.2 presents similar data and calculated SNR figure for the IQS243 device, using a 1mm Perspex/plexiglass overlay.

Table 2.1: IQS243 SNR calculation (2mm overlay)

	$Signal\ AVG_{untouched}$	$Signal\ AVG_{touched}$	Δ_{touch}	$Noise_{RMS}$	SNR	SNR_{dB}
2pF passive load	1022	465	557	0.465	1197	**62**
Moderate to strong human touch	1022	476	546	0.828	659	**56**

Table 2.2: IQS243 SNR calculation (1mm overlay)

	$Signal\ AVG_{untouched}$	$Signal\ AVG_{touched}$	Δ_{touch}	$Noise_{RMS}$	SNR	SNR_{dB}
Moderate to strong human touch	1029	326	703	0.552	1272	**62**

In general, the ***sensitivity*** of capacitive touch devices can be defined as the percentage the signal (measured in counts) change because of a touch, relative to the counts without a touch. On the other hand, the ***resolution*** of a capacitive touch device corresponds to the magnitude of the measured difference in counts, due to a touch activity. Table 2.3 presents the measured sensitivity of a typical IQS243 device, using the device setup described in Section 3.

Table 2.3: IQS243 Sensitivity measurement

$C_x\ Load$	$Signal\ _{touched}$	$*Sensitivity$
2 pF	465	54.8%
1 pF	627	39.0%
0.5 pF	752	26.9%
0.33 pF	807	21.6%
0.25 pF	830	19.3%
0.2 pF	849	17.5%
0.16 pF	852	17.2%
0.1 pF	867	15.7%

* Sensitivity calculated with an avg. untouched value = 1029 counts.

It is however worth noting, that the device sensitivity can be increased by selecting different compensation settings, whilst a larger internal Cs size will typically yield a larger resolution.

3 IQS243 SNR test setup

The test setup described in this section, was developed to enable consecutive test procedures with a consistent and established surrounding environment. As shown in Figures 3.1 and 3.2, the test setup consist of an IQS243 device, with a single channel connected to a 15x15mm copper electrode or "sense antenna", via a 60mm piece of copper wire (0.8mm diameter).

A typical 1mm or 2mm thick perspex/plexiglass overlay is set over the sense antenna and the entire setup is constructed on a 100x55x15mm polystyrene base, with a copper ground plane on the bottom. A 2-pin female SIL connector is also placed in order to populate the passive load between the sense antenna and the ground reference.

- *Please refer to the reference design in Section 4 for the circuit diagram of the IQS243 hardware.*

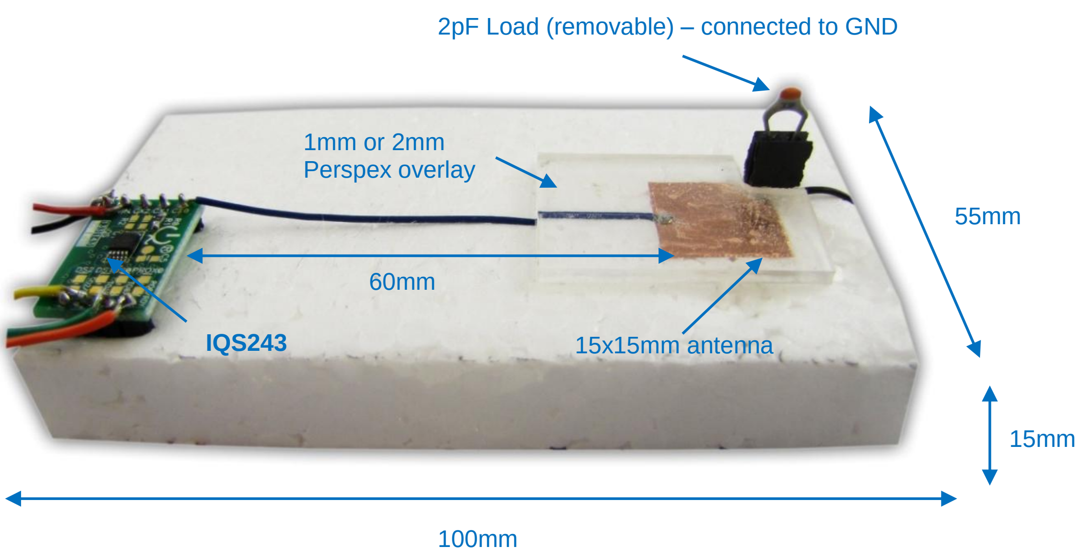


Figure 3.1: IQS243 SNR test setup – Top view

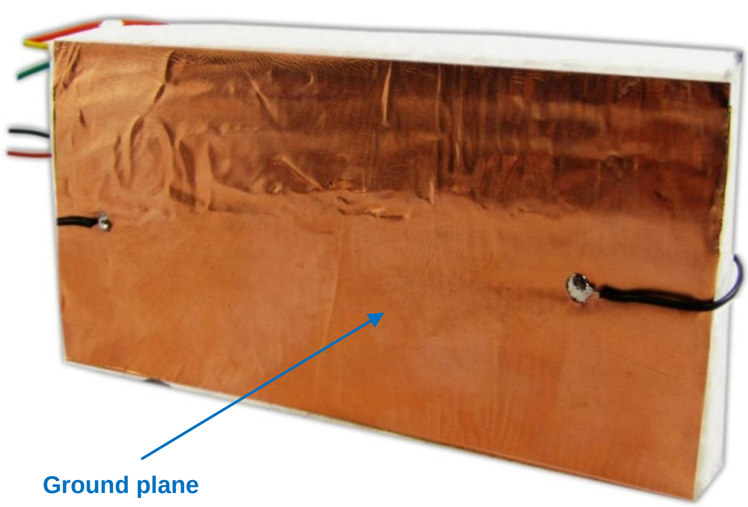


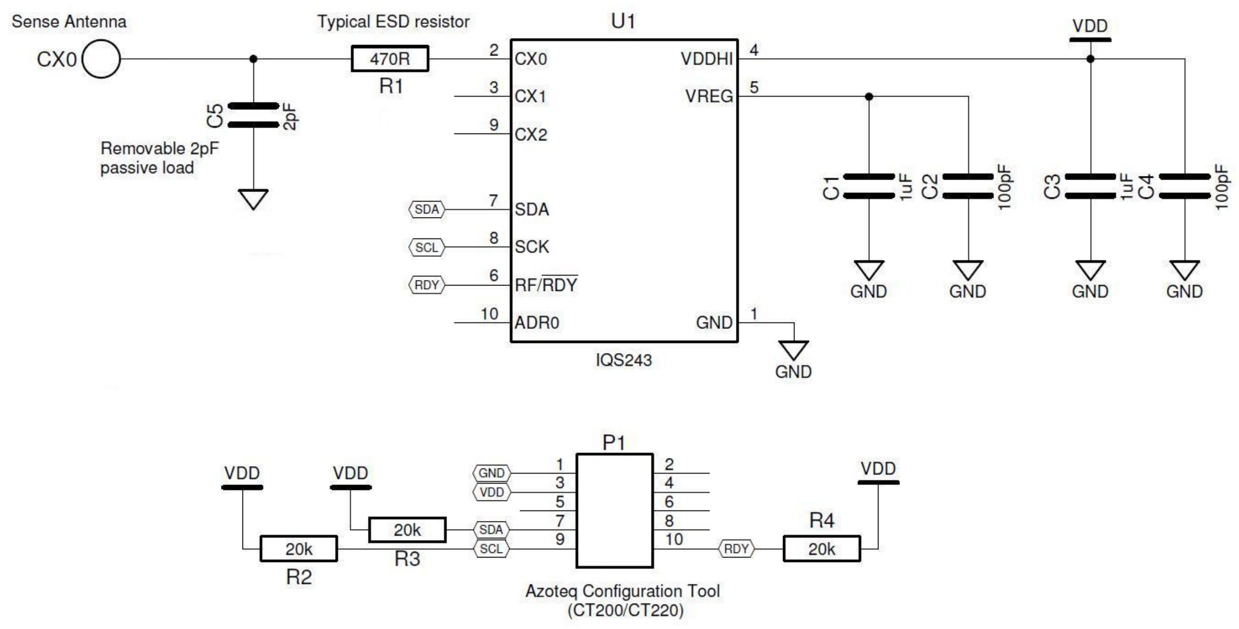
Figure 3.2: IQS243 SNR test setup – Bottom view

Table 3.1: IQS243 device settings

ATI	ON
COMPENSATION	86
MULT: SENS	3:1
MULT: COMP	13
BASE	200
CS-size	29.9pF

4 Reference design

- IQS243 reference design for SNR calculation test setup.



For **IQS243 family** and other **ProxSense®** documentation please visit:

www.azoteq.com

or email to:

ProxSenseSupport@azoteq.com

5 Conclusion

As portrayed in Tables 2.1 and 2.2, the IQS243 family ICs demonstrate remarkable SNR figures, which allows for accurate detection of touch and proximity events, even through thick overlays and air gaps. With the unique ATI functionality of ProxSense® devices, the device is automatically adjusted to deliver maximum performance in its relative environment and reliable proximity detection can be achieved for distances up to 15cm, depending on the actual application. Furthermore, the thinner overlay material (i.e. 1mm Perspex), resulted in a larger touch strength and a smaller RMS noise signal, which yielded a higher SNR figure.

Considering the measured SNR figures of the ProxSense® IQS243 device and using a piece-wise linear approximation, the smallest device sensitivity can be calculated to be between 0.2% and 0.8% (typical values for proximity detection), which relates to capacitance values in the range of 0.01 pF. *(These values are associated with the typical device settings given in Table 3.1, and may vary for different applications.)*

From the SNR results, a slight variation in RMS noise is visible for a human touch compared to that of a passive load. This is mainly due to a variation in the applied pressure and effective area of contact, between the human finger and the sensor overlay. This discrepancy however, has a negligible effective on the device's performance, resulting in excellent sensing capabilities and advanced proximity detection features for the IQS243 family of devices.

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