# Application Note: AZD079

# IQ Switch® - ProxSense® Series

## IQS213 Touch Response Rate

## Contents

# 1 Overview

## 1.1 ProxSense® IQS213

The ProxSense® **IQS213** IC is a fully integrated two or three channel capacitive swipe function sensor with market leading sensitivity and automatic tuning of the sense electrodes. The **IQS213** provides a minimalist implementation requiring few external components, with programming options and an $I^2C$ compatible interface that allow control to a host MCU for specialised applications.

The **IQS213** is a highly configurable device, which delivers touch and proximity detection using either self- or mutual capacitive sense electrodes and provides user options to implement SwipeSwitch™ features or use the device in a discrete touch key application.

**IQS213** Datasheet, Application Notes and other **ProxSense**® information available from:
**www.azoteq.com**

## 1.2 Touch response rate

Many applications require a capacitive touch controller IC with a fast response time while consuming minimal power in a reduced/low power mode. The **IQS213** is one example from the ProxSense® series of capacitive touch controllers and in this document the process to measure the touch response time will be explained.

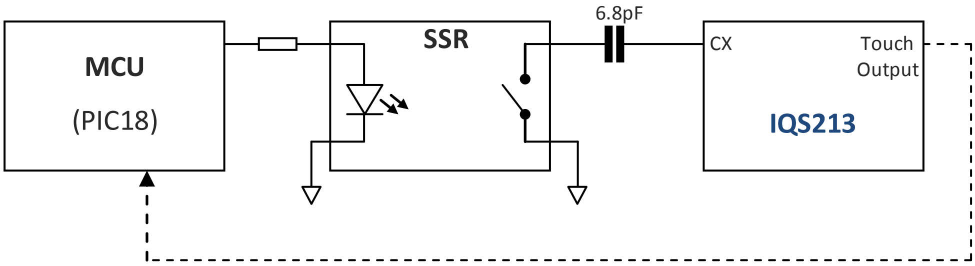


**Figure 1.1: Diagram of IQS213 setup**

Connect the **IQS213** to an MCU through a solid state relay (SSR) as shown in Figure 1.1. Note that this setup is only valid for simulating touch events on a self-capacitive sense electrode configuration.

The use of a relay is required to connect and disconnect a load capacitor (e.g. 6.8pF) to the sense electrode pin (CX), whilst isolating the sense electrode from the MCU without adding additional parasitic capacitance on the CX pin. The latter case will occur when using a transistor (e.g. NMOS-FET) to apply the load capacitor.

The MCU's peripheral clock (or an oscilloscope) is used to measure the delay between applying the load via the relay and the generated touch output signal from the **IQS213**, which is regarded as the touch response time.

## 2 Theoretical Calculation

The touch response rate of the **IQS213** is dependent on the number of active channels, the mode of operation (i.e. stand-alone / I$^2$C) and the low power setting chosen.

An example for a Stand-Alone, 3-Channel Self-Capacitance setup follows:

**a. Normal (Full) Power Mode:**

During normal power mode, the **IQS213** will charge all four channels (proximity channel + three touch channels) in a repetitive sequence of **0..1..2..3..0..1..2..3..0..**, where the period for 1 charge cycle ($t_{cycle}$) is = 2.6ms. Each channel is thus charged every fourth cycle, so the sample period for each channel ($t_{sample}$) is given by:

$$t_{sample} = 4 \text{ x } t_{cycle} = 10.4\text{ms}.$$

Furthermore, the touch outputs are debounced (up & down) by two samples, which implies that at least two consecutive samples per channel must indicate a valid touch condition for the corresponding output to be set, and at least two consecutive invalid samples for the output to be cleared again.

Depending on where in the charge sequence the load is applied, the touch report rate will vary. If the load is applied to the input for Channel 3, the slowest report rate will occur if the load is applied just before the charge cycle for Channel 0. Hence the slowest response time will be

$$t_{slowest\_resp} = 2 \text{ x } t_{sample} = 20.8\text{ms}$$

However, if the load is applied just before the charge cycle for Channel 3, the fastest response time will be:

$$t_{fastest\_resp} = 5 \text{ x } t_{cycle} = 13\text{ms}$$

Using the slowest response rate and taking into account the debounce (up & down) of 2, the **IQS213** can theoretically yield a repetitive touch rate of approximately 24 touches/second.

**b. Low Power Mode:**

During low power modes ($t_{LP}$ = 128ms for this example), the IQS213 will only charge the proximity channel (the proximity channel is a virtual channel generated by simultaneously charging all active touch electrodes) in the sequence **..0........0........0........0...**, where the period for 1 low power charge cycle ($t_{cycle\_LP}$) is approx. = 128ms.

During low power, the **IQS213** will zoom to Normal/Full Power (NP) mode whenever it detects an undebounced proximity condition on Channel 0, to allow fast touch detection. When the device has zoomed to NP, it will now charge in the NP sequence again (i.e. **..1..2..3..0..**).

Hence, if the load is applied to the sense electrode for Channel 3, the slowest report rate will occur if the load is applied just after a low power charge cycle for Channel 0 was completed. The charge sequence for this event will be **..0*.......0..1..2..3..0..1..2..3..***, where "*" indicates the start and end of the timing calculation. Thus the slowest response time will be

$$t_{slowest\_resp} = t_{cycle\_LP} + [2 \text{ x } t_{sample}] = 128\text{ms} + 20.8\text{ms} = 148.8\text{ms}$$

The fastest response time for the **first touch** during low power mode, will occur if the load is applied just before the charge cycle of Channel 0. Thus the fastest response time will again be

$$T_{fastes\_resp} = [2 \text{ x } t_{sample}] = 20.8\text{ms}$$

The **IQS213** will remain in NP mode for $t_{zoom}$ = 5s after the last touch or proximity event has cleared before returning to LP mode.

# 3 Measurement

A typical oscilloscope measurement of the example in Section 2 is shown in Figure 2. The ***Input*** represents the "touch event" (i.e. application of the load capacitor via the solid state relay), whilst the ***Output*** represents the active-high touch output of the device and the ***Charge Cycles*** the measured signal on the sense electrode / CX-pin of the **IQS213**.

Before a touch event the device is in low power (LP) mode and the charge cycle period is approx. 128ms, with only Channel 0 being active. When a touch event occurs, the device zooms to normal power (NP) mode and obtains the normal power charge cycle period of 2.6ms. After the touch event is removed, the charge cycles stay at normal power rate for $t_{zoom\,=}$ 5s, before returning to the LP mode.

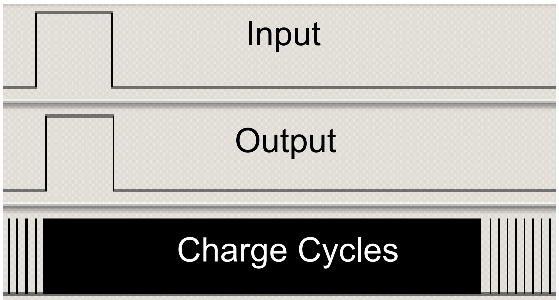


**Figure 3.1: Typical Response**

Having the **IQS213** enter LP mode ($t_{LP}$ = 128ms) every time and randomly applying the load capacitor to the input of the device via the PIC18 and the Relay, produced the following touch response times:

**Table 3.1: Measured Response Time ($t_{LP}$ = 128ms)**

| Touch event | Response time (ms) |
|---|---|
| 1 | 67.2 |
| 2 | 130.4 |
| 3 | 103.1 |
| 4 | 24.2 |
| 5 | 21.5 |

From the results in Table 2, all measured response times fell within the theoretical limits of 20.8ms to 148.8ms, which correlates very well with the anticipated response times of the **IQS213**.

***For more information on ProxSense® Series devices, please contact Azoteq or your local distributor of Azoteq ProxSense® devices.***

# Appendix A. Contact Information



| | USA | Asia | South Africa |
|---|---|---|---|
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*Please visit www.azoteq.com for a list of distributors and worldwide representation.*

The following patents relate to the device or usage of the device: US 6,249,089 B1, US 6,621,225 B2, US 6,650,066 B2, US 6,952,084 B2, US 6,984,900 B1, US 7,084,526 B2, US 7,084,531 B2, US 7,265,494 B2, US 7,291,940 B2, US 7,329,970 B2, US 7,336,037 B2, US 7,443,101 B2, US 7,466,040 B2, US 7,498,749 B2, US 7,528,508 B2, US 7,755,219 B2, US 7,772,781, US 7,781,980 B2, US 7,915,765 B2, US 7,994,726 B2, US 8, 035,623 B2, US 8,288,952 B2, EP 1 120 018 B1, EP 1 206 168 B1, EP 1 308 913 B1, EP 1 530 178 B1, ZL 200880005683.2, ZL 99 8 14357.X, AUS 761094, HK 104 14100A

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