



## IQS7223C Setup Guide

The purpose of this document is to guide the designer in setting up the IQS7223C for capacitive proximity detection using the ProxBBox demonstration device.

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## 1 Introduction

The purpose of this document is to provide a brief introduction to the initial configuration of the IQS7223C using the Azoteq IQS7223C graphical user interface (GUI) PC software. The designer may configure the IC via the GUI software for a specific application and evaluate the performance in real-time. Note that this document is not intended to discuss or address all applications, but rather to provide the user with the necessary configuration, debugging, data logging and header file export knowledge of the GUI software to address their unique application. Furthermore, the scope of this document is limited to the configuration of the IQS7223C using the appropriate and latest Azoteq IQS7223C GUI PC software. For guidelines on the hardware and electrode design, please refer to the applicable application notes. For IC-specific information, operation, and memory map details, please refer to the IQS7223C datasheet.

## 2 Getting Started

This section describes the process of initial device set-up before application-specific tuning.

### 2.1 Step 1: GUI Software Installation

Install the Azoteq IQS7223C GUI using the 'Azoteq IQS7223C Setup.exe' file and launch the software. The following window will appear upon successful launch:

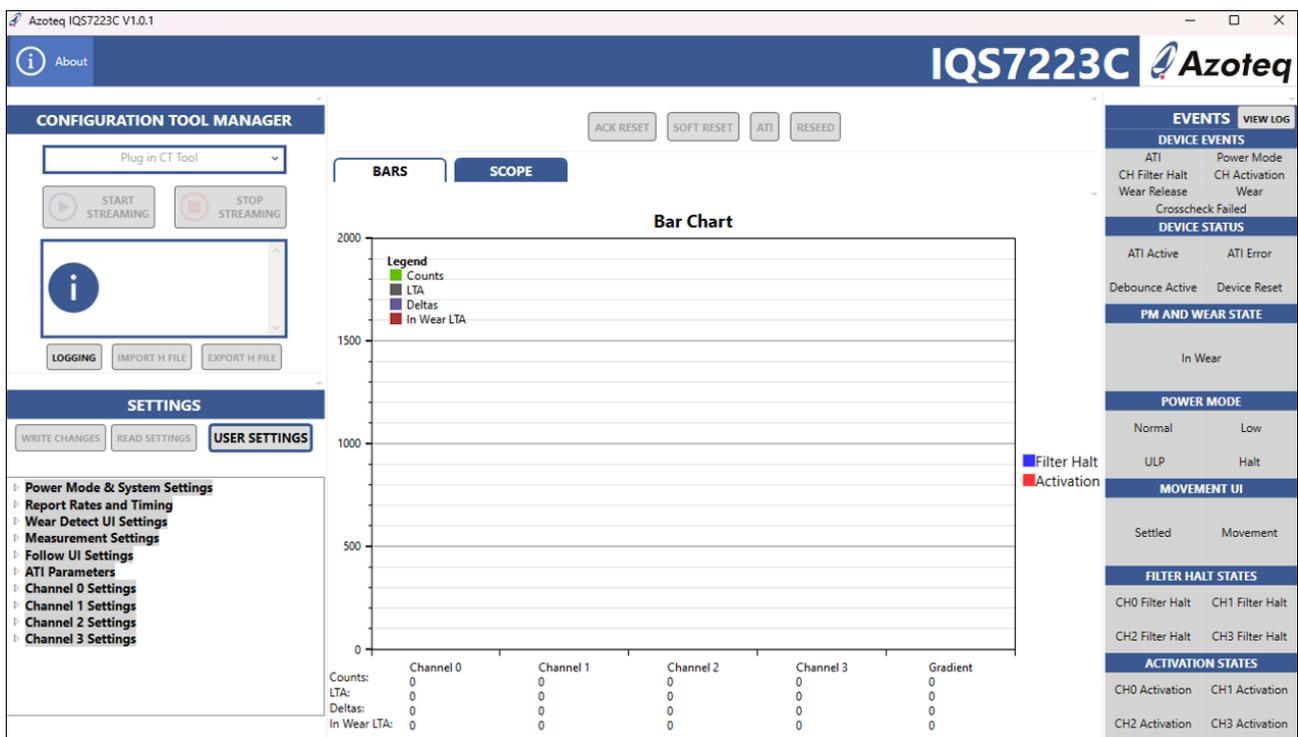


Figure 2.1: Main Window of the Azoteq IQS7223C GUI



## 2.2 Step 2: Hardware Connections

Connect your PC to the Azoteq configuration debug and display tool **CT210A** using a standard USB-micro data cable. The device under test (DUT), being either an IQS7223C EV-kit or an application PCBA with the device and required passives mounted on, can be interfaced with a suitable 20-to-10-pin ribbon cable connection (or application-specific connections) as shown in the below picture.



Figure 2.2: Hardware Connection for Streaming and Testing

Connect the application hardware’s power supply (VDD), ground (GND), I<sup>2</sup>C (SDA and SCL) as well as the data ready interrupt signal (RDY) signal traces to the **CT210A** USB dongle’s pins as shown in the pin-out table numbered and colour coded accordingly to Figure 2.3 below.

Table 2.1: CT210A Pin-out

IQS Pins	CT210A Pins
GND	Pin 1
VDD	Pin 3
SDA	Pin 7
SCL	Pin 9
RDY	Pin 10

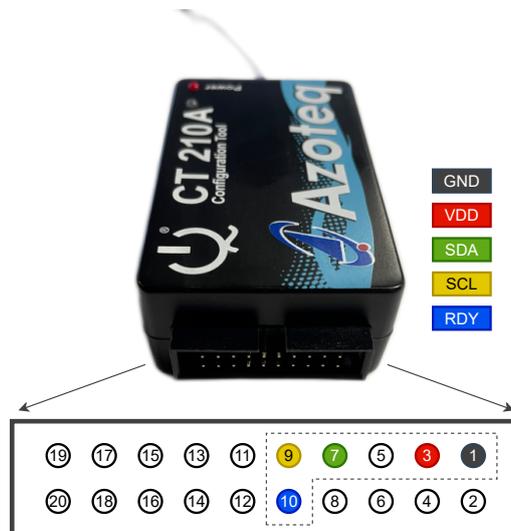


Figure 2.3: CT210A Power, I<sup>2</sup>C And RDY Connections



### 2.3 Step 3: PC Connection

After connecting the CT210A device to the computer via a USB port and micro-USB data cable, the GUI software will automatically install drivers if needed and verify their connection and firmware by displaying the CT210A's device ID and the appropriate 'Device Connected' information message in the configuration tool manager section as indicated in the red block:

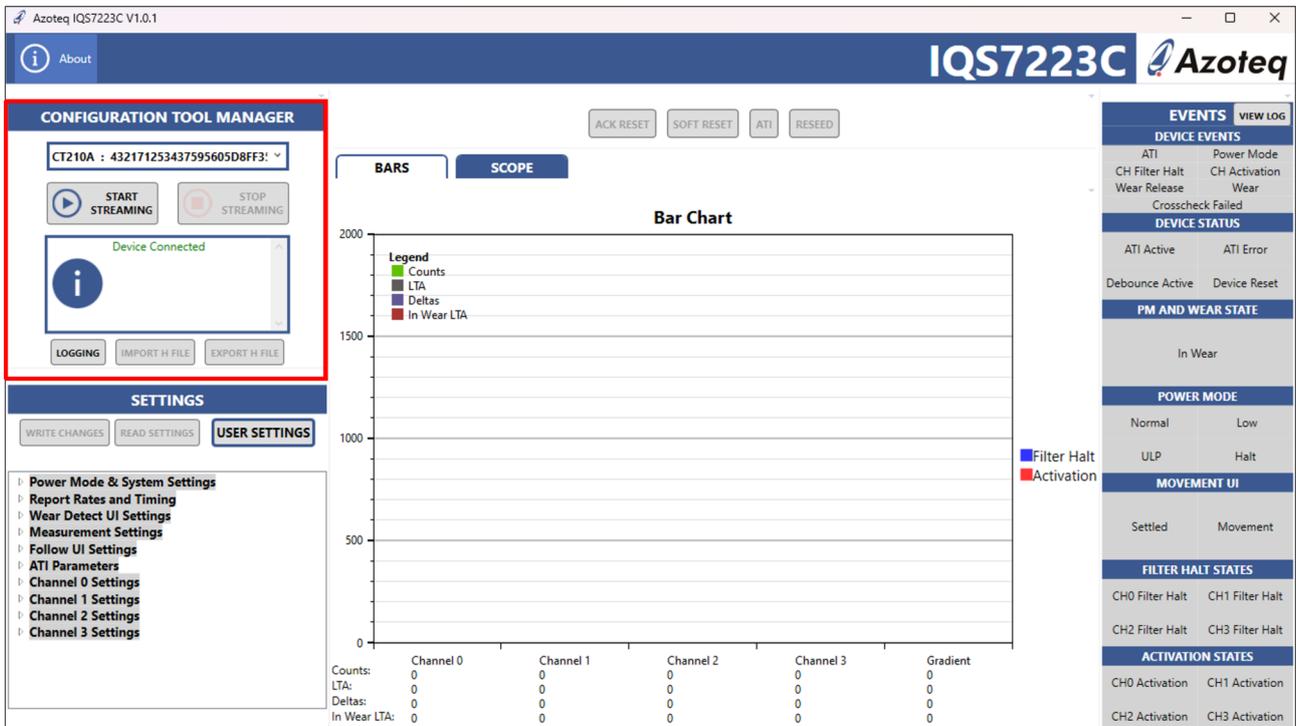


Figure 2.4: CT210A Recognition and Connection

**Note:** If the connected CT210A device firmware is out of date, an 'UPDATE AVAILABLE' button should automatically appear next to the device enumeration. This button may then be clicked to launch the appropriate CT Firmware upgrade tool to update the firmware as needed. For the image displayed in Figure 2.5 below the CT210A connected was already up to date with the latest firmware and thus not requiring an update.

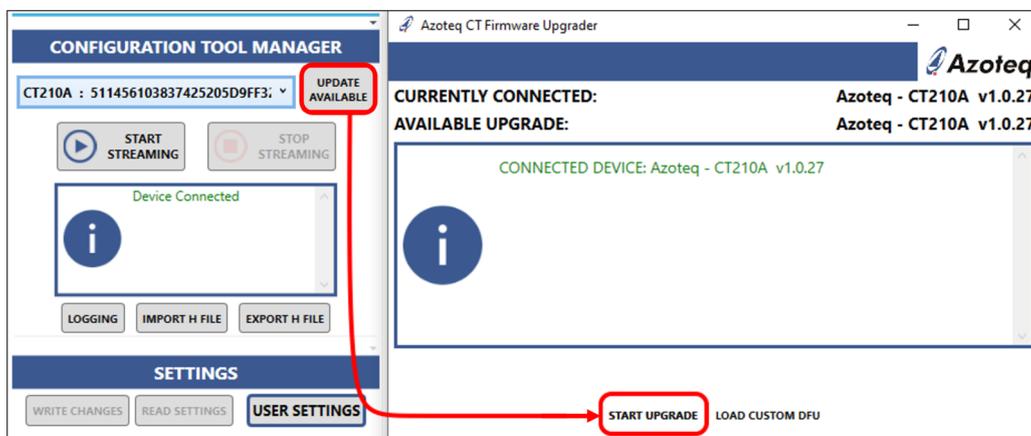


Figure 2.5: CT210A Firmware Upgrader



## 2.4 Step 4: Initiate DUT Communication (Streaming)

Click on 'START STREAMING' to initialize the serial connection to the DUT. Additional information messages will appear as listed and shown below, providing the following information:

- > Power status
- > I<sup>2</sup>C address
- > Device version information
- > Settings and streaming confirmations or errors as applicable

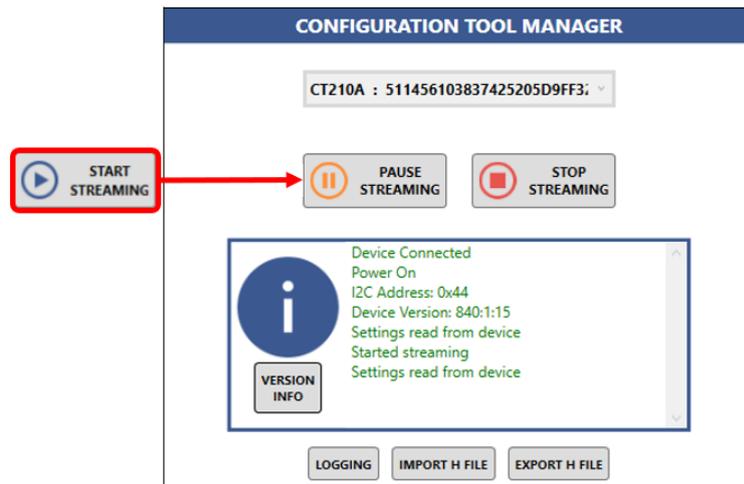


Figure 2.6: Message Dialogue Results From A Successful DUT Connection

If the above messages do not appear, please verify the device connection, the IQS part and version numbers.

## 2.5 Step 5: DUT Start-up and Initialisation

Click on 'ACK RESET' as shown in Figure 2.7. Bars will appear on Channels 0, 1, 2 and 3:



Figure 2.7: Initial Settings Stream From DUT After Reset

The device may now be configured further by either loading pre-configured settings (in a .h - header file format) or selecting the 'USER SETTINGS' button to open the pop-up window with the settings organised in menu tabs. Refer to section 4 for more detail.

**Note:** Only a single instance of the GUI software may run at any given moment and therefore, only one device can be streamed at a time. Opening multiple instances of the GUI (or other Azoteq PC software and tools) will lead to program and streaming malfunctions.

## 2.6 Step 6: Import Device Configuration (Optional)

If the device was previously configured and an associated .h-file was exported from the GUI, the file may now be imported into the GUI using the 'IMPORT H FILE' button. Additional information messages will be provided to confirm that the file has been imported correctly:

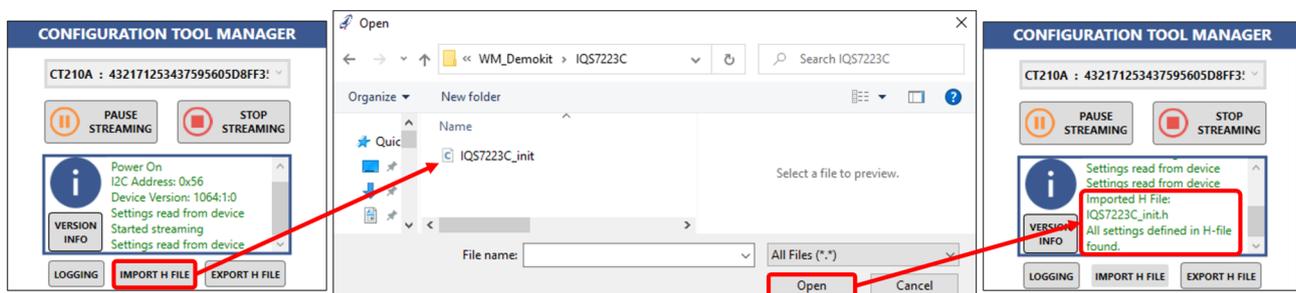


Figure 2.8: Importing a Predefined Configuration

## 2.7 Step 7: Export Device Configuration (Optional)

After the DUT has been configured, the new settings may be exported for safe-keeping, sharing or re-use at a later stage or on another device. The settings are exported as a .h-header file using the



'EXPORT H FILE' button. Take care to save the new settings file with an appropriately descriptive name and file location as intended.

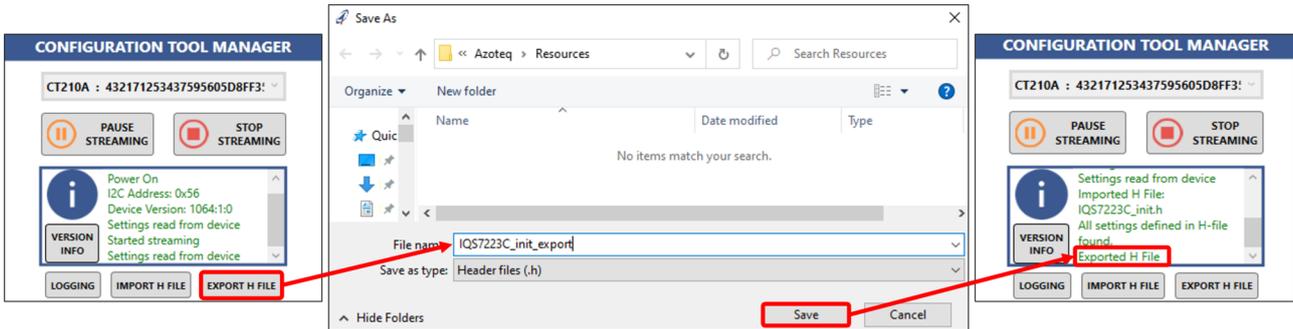


Figure 2.9: Exporting a Defined Configuration



### 3 GUI Overview

The IQS7223C graphical user interface (GUI) software allows the user to test, configure and export settings files for the IQS7223C IC. Figure 3.1 illustrates the main window and components of the GUI.

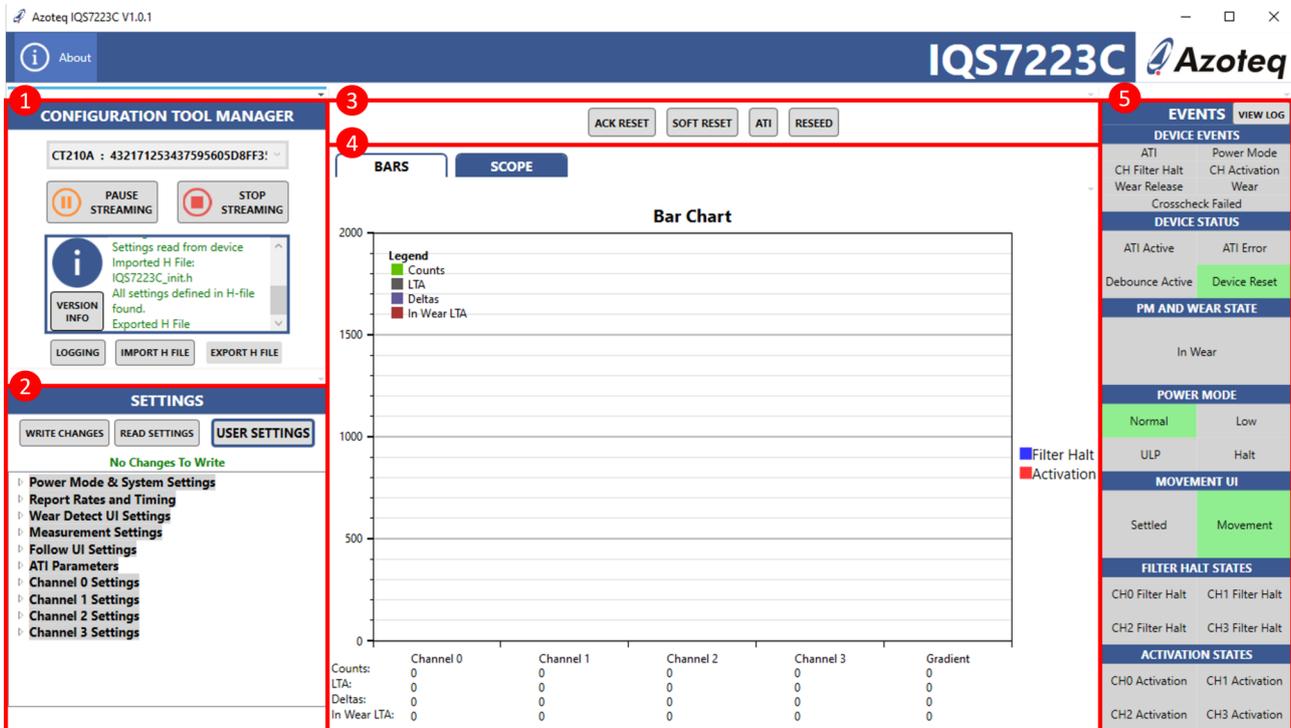


Figure 3.1: Main Window Sections of the Azoteq IQS7223C GUI

The description of each numbered item in Fig. 3.1 is as follows.

- 1. Configuration Tool Manager** - Allows for general configuration tool hardware recognition, control and feedback in the GUI. The top drop-down box will list the configuration tool (CT or DS) devices connected to the PC that are available for use. If a valid selection is made, the 'START STREAMING' button may be used to initiate I2C communication and start a data 'stream' from the DUT. If the stream was initiated successfully, the button will change to 'PAUSE STREAMING' which can temporarily pause the I2C activity from the configuration tool's side and ignore any DUT RDY signals. The 'STOP STREAMING' button in turn is used to terminate I2C communication. The text box will provide general information on the I2C connection, tasks completed, as well as error messages in case of any unsuccessful attempts or lost communications. The logging button may be used to capture/record sensor register data and export the streaming session's data to a .csv-file. The 'IMPORT H FILE' button allows the user to load a previously configured settings file (.h-file) to the DUT. The 'EXPORT H FILE' button will create/overwrite and save a new .h-file using the current configuration settings present on the DUT.
- 2. Settings Tree** - All available device settings may be found here. The 'USER SETTINGS' button will open a new, dedicated pop-up window with settings in a tabular layout for easier navigation and display. The settings tree shown below the buttons contains the same settings, as well as some hidden engineering settings in numerical order according to the memory map addresses. It is advised that the user utilise the 'USER SETTINGS' interface as the primary configuration portal. Except for some settings described later in this document, the settings tree should not be used without the support of an Azoteq or distributor FAE.



- 3. System Commands Section** - The 'ACK RESET' button will issue a reset acknowledgement command to the IC as confirmation of coming from a power-on / reset state (with default device settings populated). The 'SOFT RESET' button will command the DUT to perform a soft reboot. The 'ATI ALL AND READ' button will command the DUT to use its automatic tuning implementation (ATI) algorithm for sensor re-calibration (please refer to the IQS7223C datasheet for more information). The 'RESEED' button commands the DUT to seed/set its Long Term Average (LTA) filtered values equal to its current count values. Note: these operations apply globally to all channels or the device as a whole.
- 4. Bar And Scope View** - This area will visually display bar graphs of the sensor counts and LTA signals as configured for every channel. The decimal representation of the current values is displayed below each channel. The results may be viewed on the bars (by selecting the primary 'BARS' tab) or the same data stream can be plotted as lines over time on a secondary scope view (by selecting the 'SCOPE' tab). The 'Counts' value represents the filtered signal input from the device's sensors. The 'LTA' is the long-term average of the counts and acts as a slow adjusting baseline used as a reference to detect any quick deviation in Counts. The channel's Counts and LTA line plots can be selected or deselected for display to make the scope view less cluttered. Adjusting the number of points on the x-axis requires that one presses the 'RESET X AXIS' to apply/update the scope view. For scope navigational control explanations please click on the 'HELP' button.

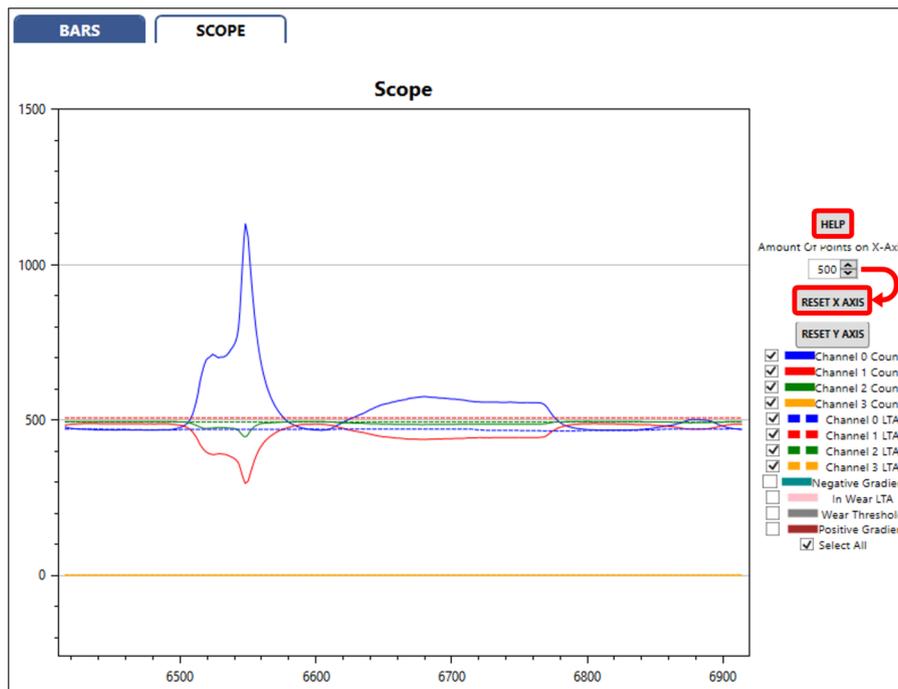


Figure 3.2: Scope View of the IQS7223C GUI (Alternative Display for Bar View)

- 5. Events Flags Section** - Provides an overview of various events that are triggered. Individual blocks will light up for event occurrences or trigger activation states and a text log of specific event selections can also be evaluated in an event log (timestamped text) terminal.
  - > **Events**
    - **Device Events**
      - \* **ATI**. Active when ATI routine execution starts.
      - \* **Power Mode**. Active when power mode switches.
      - \* **Channel Filter-halt**. Active when a channel enters or exits a filter halt state (indicated by a bar graph changing from green to blue).



- \* **Channel Activation.** Active when a channel enters activation state (user is detected, indicated by a bar graph changing from blue to orange).
- \* **Wear Release.** Active when the DUT exists wear state.
- \* **Wear.** Active when the DUT enters wear state
- \* **Crosscheck Failed.** Active when in-wear ATI routine was unsuccessful.
- **Device Status**
  - \* **ATI Active.** Active until ATI routine execution is complete. Similar to the ATI flag in the 'Device events' section.
  - \* **ATI Error.** Active when ATI routine was attempted but failed. The most common cause for this error is a too-sensitive channel configuration.
  - \* **Debounce Active.** Active when the de-bounce routine is executed. This will be dependent on the number of debounce cycles selected in a channel's 'Filter Halt' settings.
  - \* **Device Reset.** Active after a device reset. Remains active until reset is acknowledged with the 'ACK RESET' button.
- **PM and Wear State**
  - \* **In Wear.** This is the main 'In Wear' status flag. It remains active as long as a successful wear state is detected. Deactivates upon a successful wear release event.
- **Power Mode**
  - \* **Normal.** Active while the DUT is in Normal power (NP) mode.
  - \* **Low.** Active while the DUT is in Low power (LP) mode.
  - \* **ULP.** Active while the DUT is in Ultra low power (ULP) mode.
  - \* **Halt.** DUT is in halt mode; communication and sampling are seized.
- **Movement UI**
  - \* **Settled.** Active while the DUT detects no movement as derived from a low variance/gradient on CH0 and the wear settle time has passed. Pre-cursor to the activation of the 'In Wear' flag.
  - \* **Movement.** Active while the DUT detects movement, denoted by high variance/-gradient events on CH0.
- **Filt Halt States**
  - \* **CH0 Filt Halt.** Active while CH0's LTA filter is halted.
  - \* **CH1 Filt Halt.** Active while CH1's LTA filter is halted.
  - \* **CH2 Filt Halt.** Active while CH2's LTA filter is halted.
  - \* **CH3 Filt Halt.** Active while CH3's LTA filter is halted.
- **Activation States**
  - \* **CH0 Activation.** Active while CH0 is activated.
  - \* **CH1 Activation.** Active while CH1 is activated.
  - \* **CH2 Activation.** Active while CH2 is activated.
  - \* **CH3 Activation.** Active while CH3 is activated.



## 4 Application Example

This section will use the *ProxB* EV-kit hardware as an example application of the IQS7223C, aimed specifically at keyboard proximity design. For more detailed information on keyboard proximity design, please refer to the AZD130 design guide document.

Figure 4.1 show the IC and relevant passive components. In this example, we aim to detect when a user approaches the keyboard. Therefore, we must design for maximum detection coverage over the entire keyboard region. The best way to achieve this is to use the metallic surface of the keyboard as the electrode plate and connect it to the IQS7223C in a self-capacitance configuration. Figure 4.1 shows that the CRX3 pin of the IQS7223C is connected to the metallic electrode plate (Crx3), as indicated by the red block.

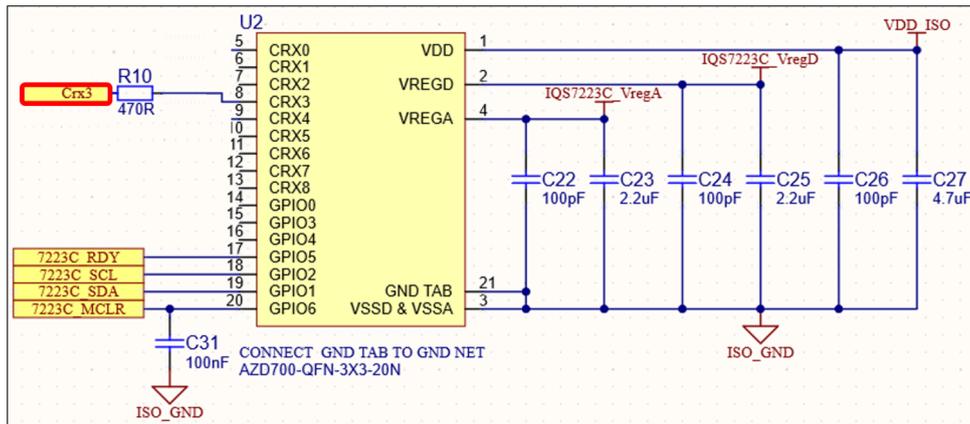


Figure 4.1: IQS7223C Schematic Layout: IC With Passives

Figure 4.2 shows the *ProxB* example application, with its metallic surface as electrode plate Crx3. Additionally, a connection PCB is used to bridge the communication connection from an FPC tail to the ribbon cable used by the CT210A. Note that the *ProxB* has two FPC connections on the right side - the top connection (as shown here) must be used for communication with and debugging of the IQS7223C.

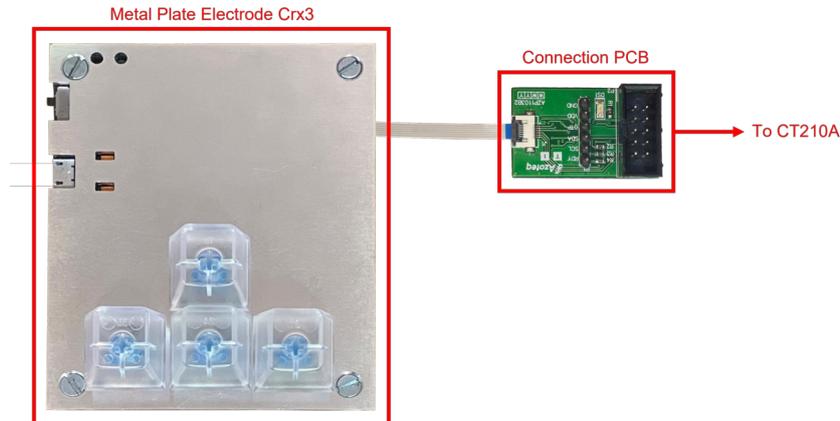


Figure 4.2: ProxB Demo Kit With Connection Board

The sections that follow will elaborate on the relevant sensor settings that may be adjusted. As such, the reader is advised to load the predefined configuration settings as discussed in 2.6.



## 4.1 Channel Setup

The relevant settings for channel setup are shown in Figure 4.3.

1. **Sensing Mode.** The IQS7223C has three different sensing modes, namely *Self-capacitance*, *Mutual-capacitance* and *Temperature Mode*. Additionally, by selecting the mutual capacitance mode and selecting pins in the 'Cm Tx Selection' at the bottom of the window, a fourth mode called *Differential-capacitance* is activated. In general and for this demo kit, the self-capacitance method is recommended.
2. **Channel Enable.** This needs to be selected for the sensor to function.
3. **Frequency Fraction & Period.** These settings determine the charge transfer frequency or the rate at which the electrode is measured. The settings shown here relate to a frequency of 250 kHz which is the recommended value. For other frequencies, please refer to the IQS7223C datasheet.
4. **Cs Size.** This is the size of the reference capacitor used by the IQS7223C for sensing calculations, and two sizes are selectable: 40 pF and 80 pF. The 80 pF option is recommended.
5. **Rx Selection.** The IQS7223C allows up to four pins (CRX0 to 3) to be selected as inputs. As per Figure 4.1, only CRX3 is used, and must therefore be selected.

Settings

### Channel 0 Settings

General System Settings

Report Rates and Timeouts

Wear UI Settings

Filter betas

CH0 & 1 Follow UI Settings

CH2 & 3 Follow UI Settings

Follow Weight

Compensation Adjustment

Channel 0 Settings

Channel 1 Settings

Channel 2 Settings

Channel 3 Settings

Channel 0 ATI Parameters

Channel 1 ATI Parameters

Channel 2 ATI Parameters

Channel 3 ATI Parameters

Channel 0 Thresholds

Channel 1 Thresholds

Channel 2 Thresholds

Channel 3 Thresholds

**Sensing Mode:** SelfCap Mode

Channel Enable

**Frequency Fraction:** 127

**Frequency Period:** 26

**Max Counts:** 4096

**Cs Size:** 80 pF

**Internal Calibration Capacitor Size:** 0 pF

**Projected Bias Select:** 10 µA

Bi-directional Sensing Enabled

Internal Cap Removes Charge

Internal Calibration Capacitor

Disable Compensation

VRef 0v5 Enable

Invert

Linearize Counts

**Rx Selection**

CRx0  CRx1  CRx2  CRx3

**Channel Input**

Offset Current  Temperature

**Tx Selection**

CTx0  CTx1  CTx2  CTx3  CTx4  CTx5  CTx6  CTx7  CTx8

CTx10  CTx11

**Cm Tx Selection**

CTx0  CTx1  CTx2  CTx3  CTx4  CTx5  CTx6  CTx7  CTx8

CTx10  CTx11

WRITE CHANGES READ SETTINGS

No Changes To Write

Figure 4.3: IQS7223C Channel Settings Window



## 4.2 Sensitivity Adjustment

The settings shown in Figure 4.4 are applicable for adjusting the sensitivity of the sensor. Concerning the *ProxB*ox, higher sensitivity means that a user will be detected from further away. Conversely, lower sensitivity means users will only be detected when they are very close to the device. Keep in mind that a highly sensitive sensor setup will be susceptible to noise, which might lead to false detections.

1. **ATI Base & Target.** The IQS7223C has an automatic sensor calibration system, called the *Automatic Tuning Implementation* or *ATI*, to ensure that the IQS7223C always has the same sensitivity level in different environmental circumstances. The system performs its calibration based on two values, namely the 'ATI Base' and 'ATI Target'. These two values will determine the sensitivity of the sensor. The recommended settings are an ATI Base of 200 counts and a target value of 2000 counts. For a more sensitive configuration:
  - > Decrease the ATI base value (minimum 100 counts)
  - > Increase the ATI target value (maximum 2000 counts)

For a less sensitive configuration:

- > Increase the ATI base value (maximum 200 counts)
- > Decrease the ATI target value (minimum 500 counts)

2. **ATI Mode.** This setting determines the mode of the ATI algorithm. It is recommended to have it set at 'Full'.

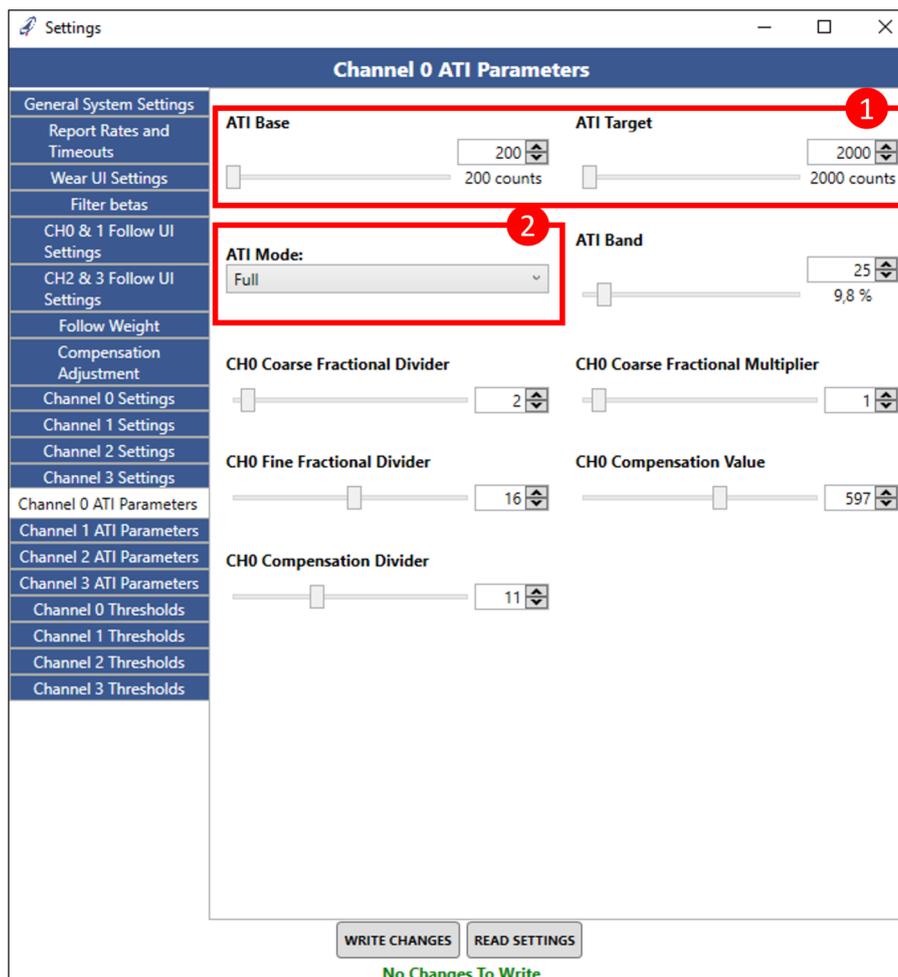


Figure 4.4: IQS7223C ATI Adjustment Settings



### 4.3 Threshold Adjustment

Apart from adjusting the ATI Base and Target values (as discussed in Section 4.2) for sensitivity, the threshold settings of the sensor may also be adjusted to achieve the same goal. The threshold value is defined as the minimum counts change percentage required for the IQS7223C to register a detection, or to set the 'Channel Activation' flag. Thus, by lowering the threshold, the perceived sensitivity of the device may be changed.

1. **Activation Timeout.** This sets the period before the device clears the activation flag and recalibrates. When this value is set to zero, the channel activation flag is persistent. While a persistent flag is ideal for some applications, it is best to have a temporary activation flag for keyboard applications which is shown here for the *ProxB* as 5000 ms.
2. **Activation Threshold.** The threshold value shown here is the percentage change in counts required before the IQS7223C registers a user detection, which leads to the channel activation flag being set. A lower threshold value will increase the perceived sensitivity of the device.

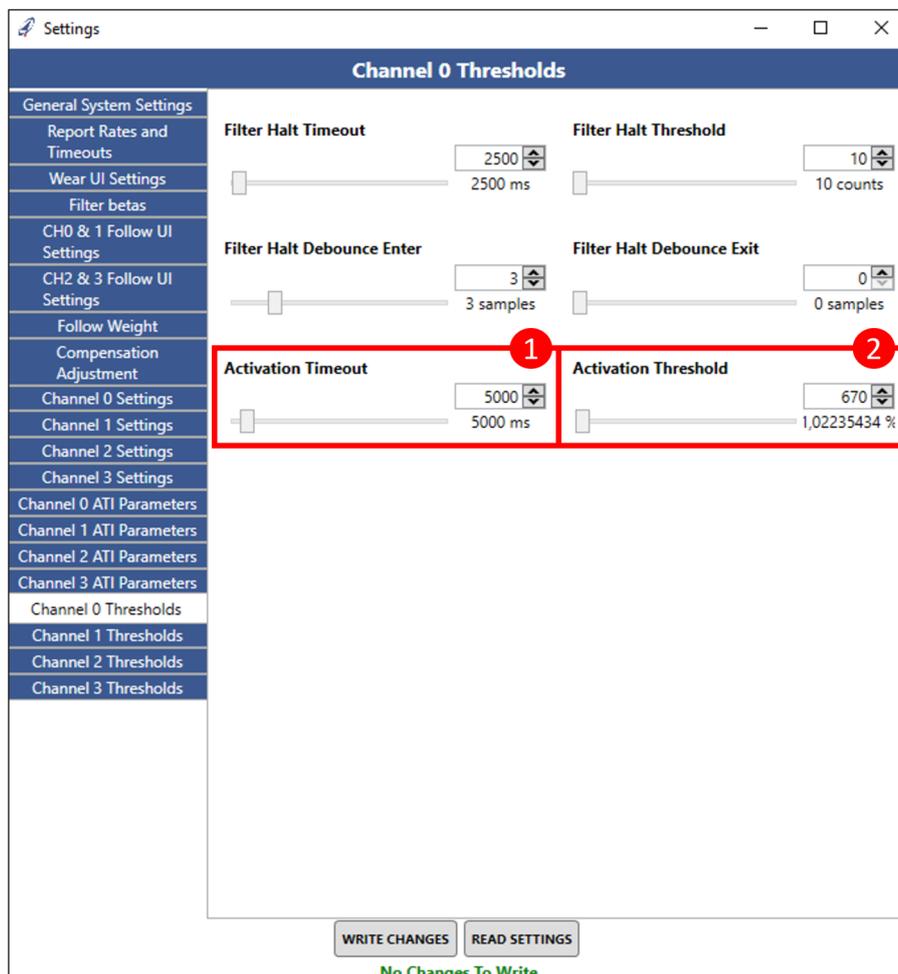


Figure 4.5: IQS7223C Threshold Adjustment Settings



## 4.4 Noise Suppression

It is possible to suppress the signal noise to an extent at high-sensitivity configurations by adjusting the appropriate filter beta value. Figure 4.6 shows the filter beta settings window of the IQS7223C. The beta filter value that applies to the self-capacitance method (as recommended for keyboards) is shown in the red block. A higher beta value will increase noise suppression but will reduce overall sensor responsiveness. Conversely, a lower beta value will increase noise amplitude but also increase overall sensor responsiveness. The recommended value for the beta value is 2, and the maximum allowable value is 5.



Figure 4.6: IQS7223C Beta Filter Settings

## 5 Conclusion

This document explained the general guidelines for streaming and testing the IQS7723C IC using the ProxBow keyboard device as an application example. For more detailed guidelines, please refer to the relevant application note and IQS7223C datasheet. Alternatively, please contact Azoteq for assistance.



## 6 Revision History

Release	Date	Comments
v1.0	2023/06/23	Initial document released



## Contact Information

	USA	Asia	South Africa
<b>Physical Address</b>	11940 Jollyville Suite 120-S Austin TX 78759 USA	Room 501A, Block A T-Share International Centre Taoyuan Road, Nanshan District Shenzhen, Guangdong, PRC	1 Bergsig Avenue Paarl 7646 South Africa
<b>Postal Address</b>	11940 Jollyville Suite 120-S Austin TX 78759 USA	Room 501A, Block A T-Share International Centre Taoyuan Road, Nanshan District Shenzhen, Guangdong, PRC	PO Box 3534 Paarl 7620 South Africa
<b>Tel</b>	+1 512 538 1995	+86 755 8303 5294 ext 808	+27 21 863 0033
<b>Email</b>	info@azoteq.com	info@azoteq.com	info@azoteq.com

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