IQS396 and IQS397 User Guide

The user guide introduces the development tools available for the product and guides the setup of certain key elements.

Contents

1 Introduction

This document provides an overview of the IQS396 and IQS397 ProxFusion® devices, the graphical user interface (GUI), and the IQS396 and IQS397 evaluation (EV) kits. It aims to equip users with the knowledge needed for configuring, debugging, data logging, and header file export using the GUI software to address their unique applications.

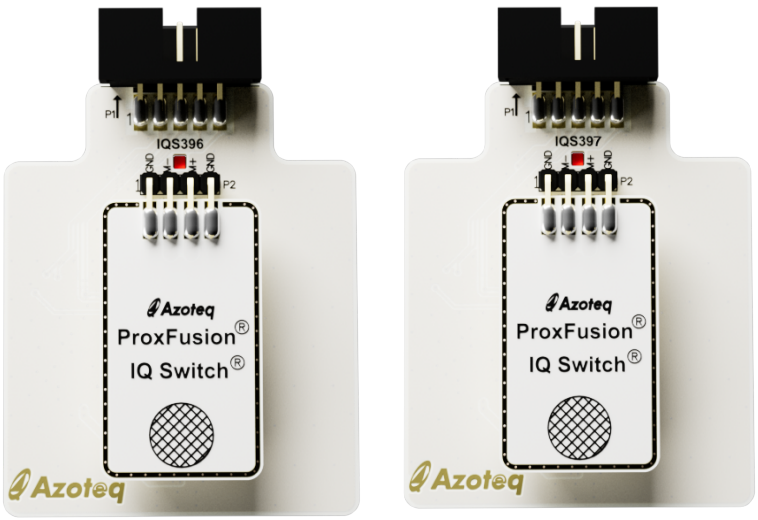
The firmware that runs on both IQS396EV02 and IQS397EV02 EV kits are very similar but differ in the way the haptics parameters are configured. The differences between the two devices are shown in Table 1.1.

Table 1.1: Differences Between IQS396 and IQS397

Parameters	IQS396	IQS397
Haptics waveform	Multiple waveform can be selected and configured	Single waveform
Haptics patterns	Multiple patterns can be selected and configured	Single pattern
Haptics drive settings	Drive settings configured using multiple bytes	Drive settings configured using a single byte
Haptics drive stages	Up to five drive stages	Up to three drive stages

The IQS396EV02 and IQS397EV02 EV kits each consist of a single module showcasing the different sensing technologies that the IQS396 and IQS397 provide. See the IQS396EV02 and IQS397EV02 reference schematics in Section 5.

- Single channel inductive sensing module that showcases the use of PCB coils for proximity and touch button applications,



(a) IQS396EV02 *(b) IQS397EV02*

Figure 1.1: IQS396 and IQS397 EV02 EV Kit

The following application notes provide background information and design guidelines for the various sensing methods supported by the IQS396 and IQS397.

- Azoteq Sensing Technologies: AZD004
- Capacitive Sensing Design Guide: AZD125
- Inductive Design Layout Guide: AZD115

For IC-specific information, operation, and memory map details, please refer to the IQS396 Datasheet and IQS397 Datasheet.

2 Getting Started

This section describes the process of initial device and GUI set-up prior to application-specific tuning.

2.1 Step 1: GUI Software Installation

Download and install the Azoteq IQS396 or IQS397 GUI PC Software from the Azoteq website under the Software and Tools page. Extract the downloaded zip file and follow the installation wizard procedure.

2.2 Step 2: Launch GUI Software

Launch the IQS396 or IQS397 GUI software executable. The following window should appear:

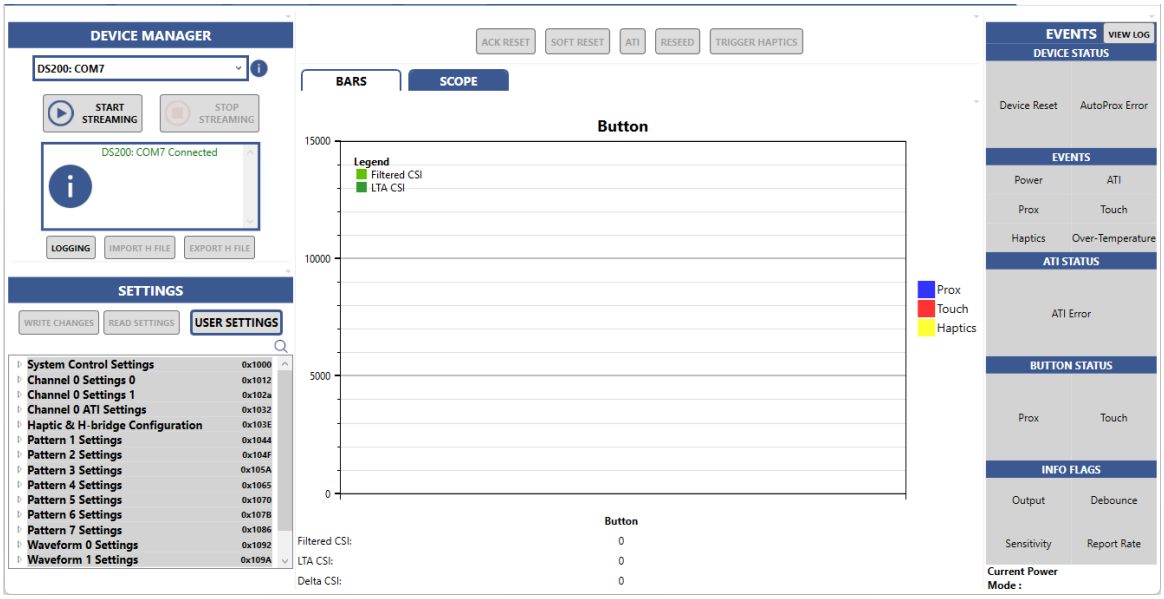


Figure 2.1: GUI Main Window

2.3 Step 3: Hardware Connections

Connect the DS200 to your PC, using a standard type-C cable. The device under test (DUT), being either an IQS396EV02 or IQS397EV02 EV kit or an application PCBA, can be interfaced with a suitable 10-to-10 pin ribbon cable connection (or application-specific connections), as shown in Figure 2.2 below.

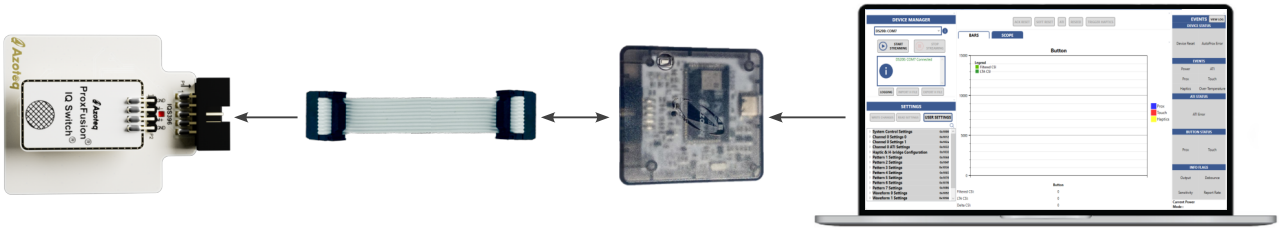


Figure 2.2: DS200 Connection for Streaming and Testing

Note: The CT210A can be used instead of the DS200, along with a standard USB-micro data cable and a suitable 20-to-10 pin ribbon cable connection, as shown in Figure 2.3 below.

Figure 2.3: CT210A Connection for Streaming and Testing

If a custom cable or hardware is used, please refer to Table 2.1 and Figure 2.4 for the required connections.

Table 2.1: DS200 Pin-out

IQS Pins	DS200 Pins
GND	Pin 1
VDD	Pin 3
SDA	Pin 7
SCL	Pin 9
RDY	Pin 10

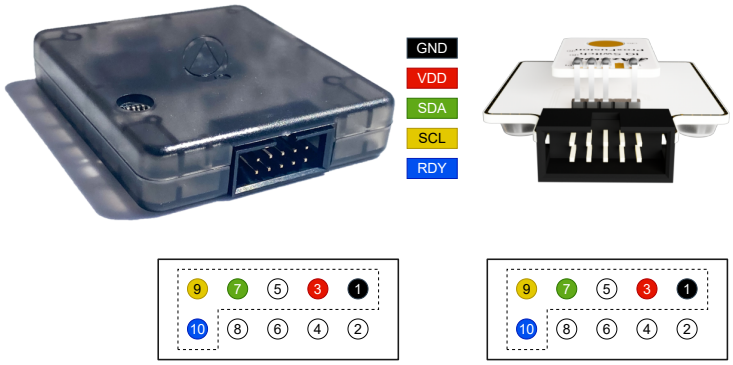


Figure 2.4: DS200 Power, I^2C and RDY Connections

2.4 Step 4: PC Connection Verification

After connecting the DS200 device to the computer, the GUI software will automatically install any necessary drivers. It will then verify the DS200 connection and firmware version, displaying a 'Device Connected' message in the configuration tool manager section, as shown in the red block in Figure 2.5.

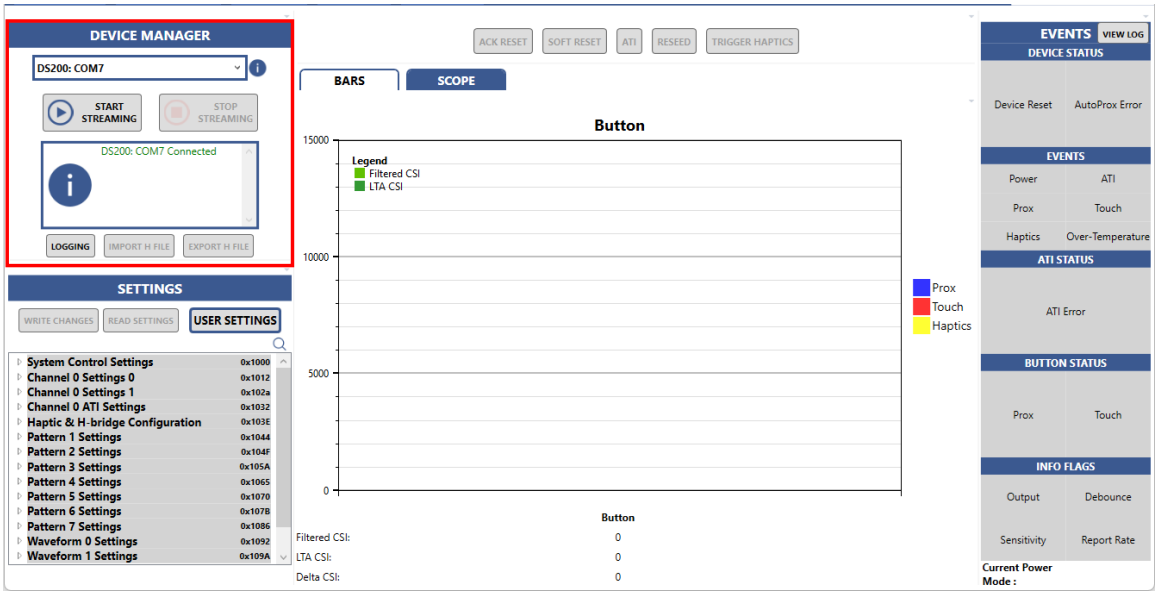


Figure 2.5: DS200 Recognition and Connection

Note: If the connected DS200 device firmware is out of date, an 'Update available' button should automatically appear next to the device enumeration. Click this button to launch the Azoteq firmware upgrade tool and update the firmware, as shown in Figure 2.6.

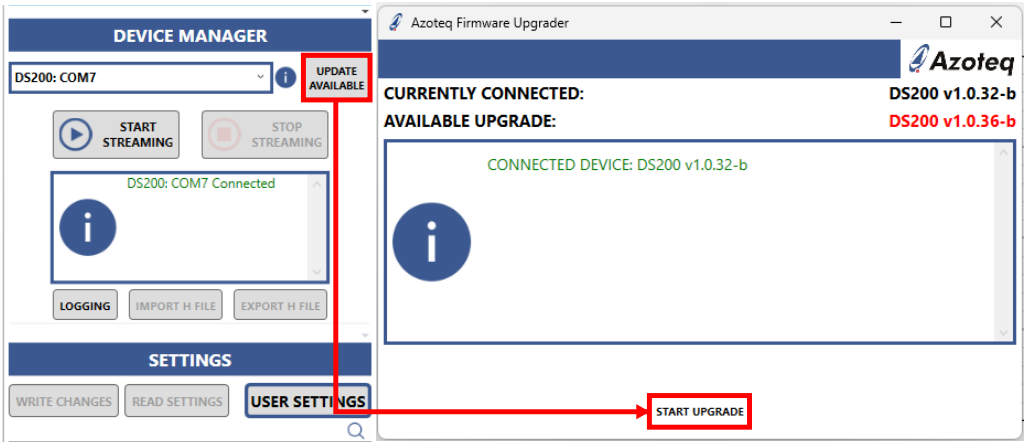


Figure 2.6: DS200 Firmware Upgrade

2.5 Step 5: Initiate I²C Communication (Streaming)

Click on 'Start Streaming' to initiate communications with the IQS396 or IQS397. Additional messages will appear and will provide the following information:

- Power status
- I²C address
- Device version information
- Settings and streaming confirmations or errors, as applicable

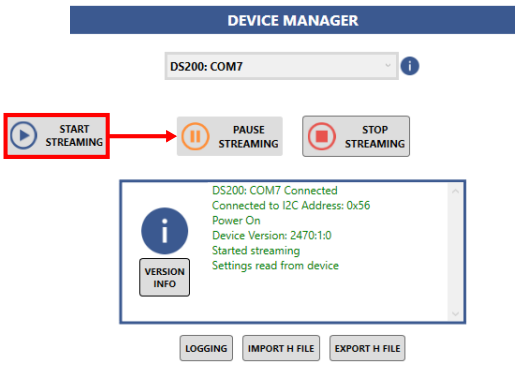


Figure 2.7: Message Dialogue Results from a Successful IQS396 and IQS397 Connection

If an error is displayed, please ensure that the device is properly connected and that the IQS396 or IQS397's product and version numbers were verified successfully.

2.6 Step 6: Acknowledge Reset and Streaming Mode

Click on the red text button 'ACK Reset' to clear the reset event flag. The 'ACK Reset' text should change colour to black, indicating successful reset acknowledgement.

Figure 2.8: ACK Reset Button

The device starts in streaming mode, as shown in Figure 2.9. The default settings may not be an appropriate baseline for a production application.

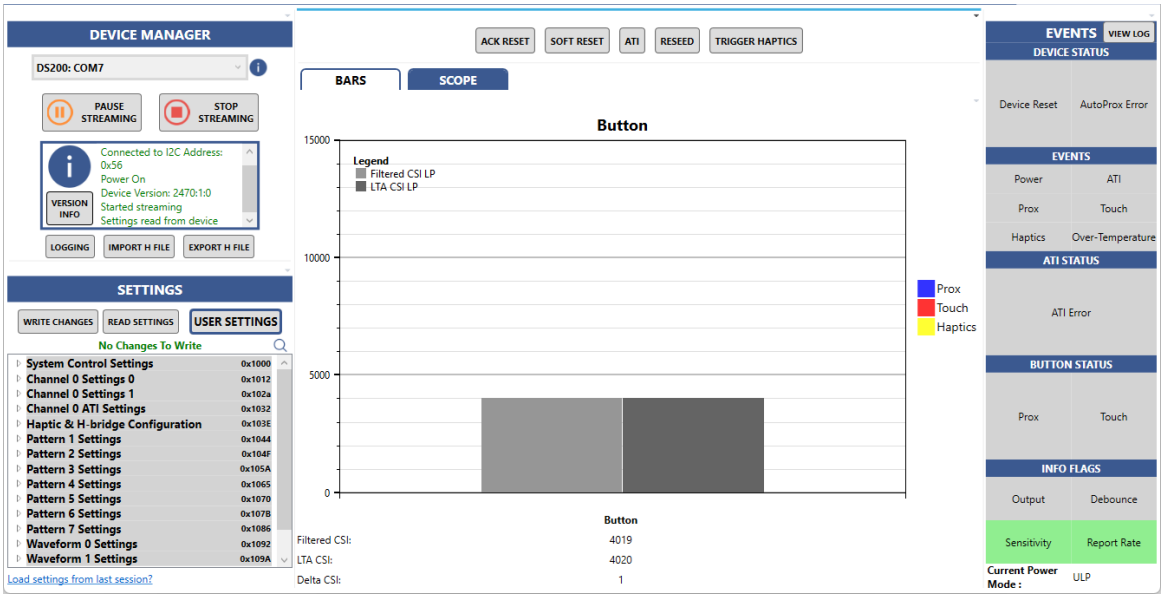


Figure 2.9: IQS396 and IQS397 Streaming

3 Debug and Display Software Overview

This section briefly explains the GUI elements such as the sensor graphs, device events, and commands, as well as some additional core functionality such as data logging and exporting of device settings.

3.1 IQS396 or IQS397 Streaming Data

The IQS396 and IQS397 supports only a single ProxFusion® channel. The “filtered linearised counts” of the channel is a representation of the signal strength measured by the sensor.

The IQS396 and IQS397 GUI displays the filtered linearised counts of the channel in the graph panel in the centre of the GUI. The default graph view is the bar graph, which plots the instantaneous filtered linearised counts of the channel.

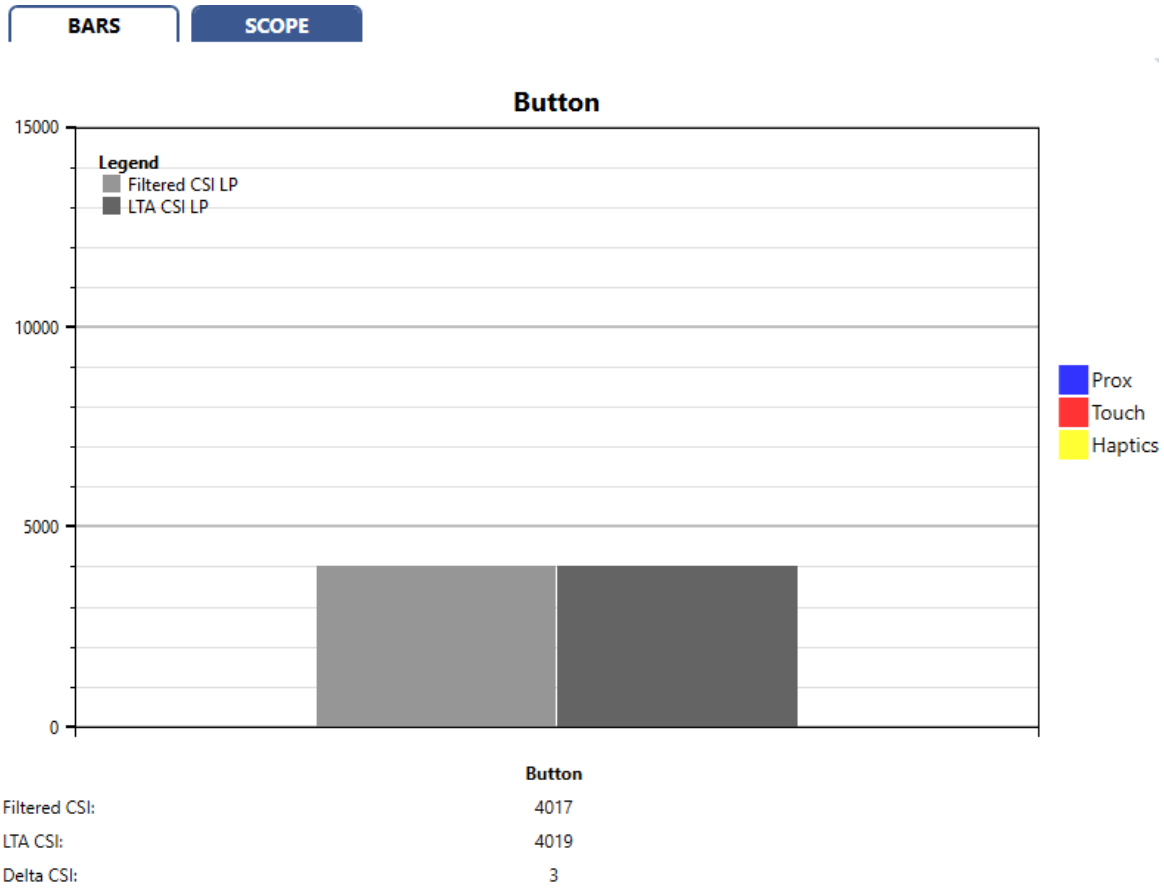


Figure 3.1: Streaming Graphs

The graph views can be manipulated with the following controls:

- Scroll wheel to zoom in and out.
- Hold and drag middle-mouse button to zoom to a bounding box.
- Hold and drag right-mouse button to pan.
- Double left-click to reset the graph view.

Note: All the signals recorded in the graphs are read directly from the IC. For more information regarding the register map, please consult the IQS396 Datasheet or IQS397 Datasheet.

3.1.1 Bar Graph

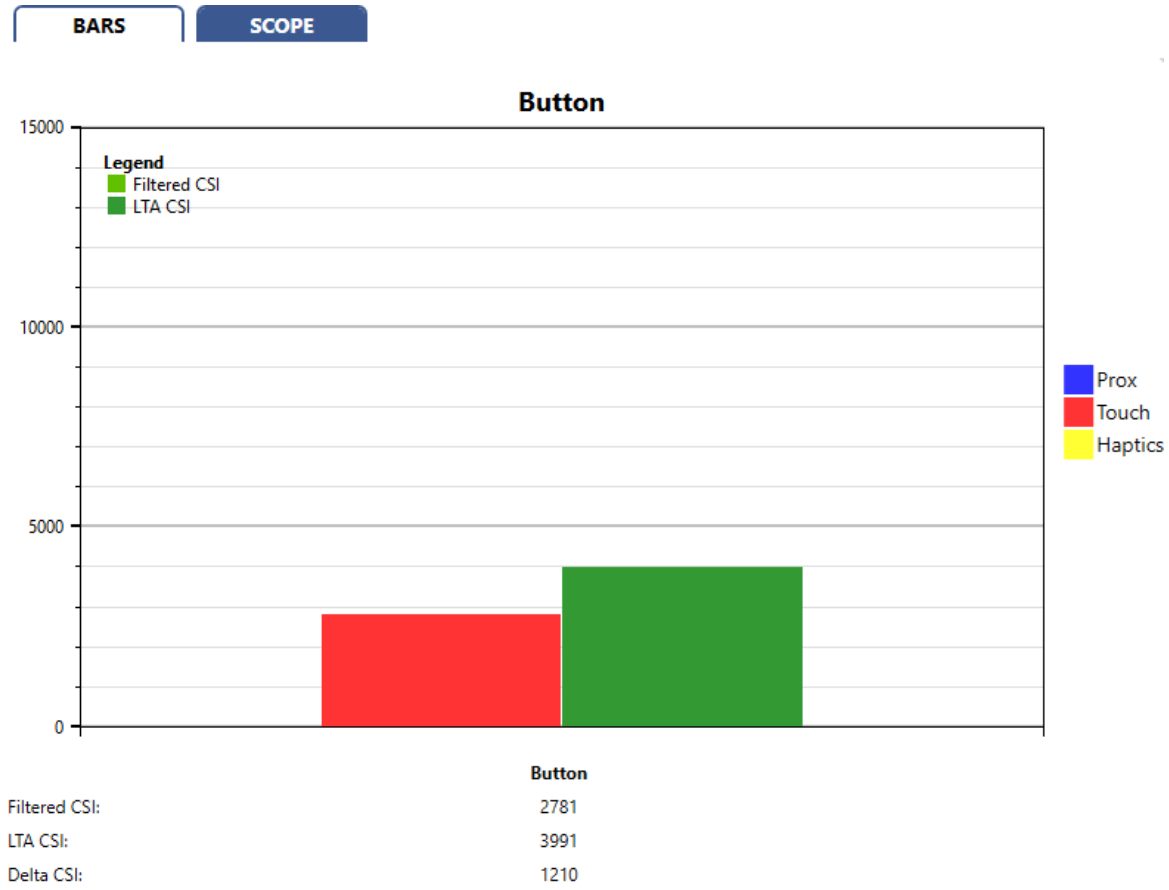


Figure 3.2: Bar Graph View of Channel Counts

For the ProxFusion® channel, the bar graph shows the "filtered linearised counts" of the capacitive/inductive sensor. The **"filtered linearised counts" (filtered CSI)** value shows the filtered value of the linearised raw measurement of the sensor. The **LTA CSI** is the Long Term Average of the filtered CSI signal. It tracks slow variations in the environment, and is used as a reference to detect the channel proximity/touch events. The **Delta CSI** is simply the difference between the LTA and the counts, and is used to detect user interaction by comparing it to the proximity/touch threshold.

3.1.2 Scope View

The scope view plots the counts and LTAs of each ProxFusion® channel over time.

The data in the current view of the scope can be saved to a CSV file. To save the data, first click 'Pause Streaming' as shown in Figure 3.3.

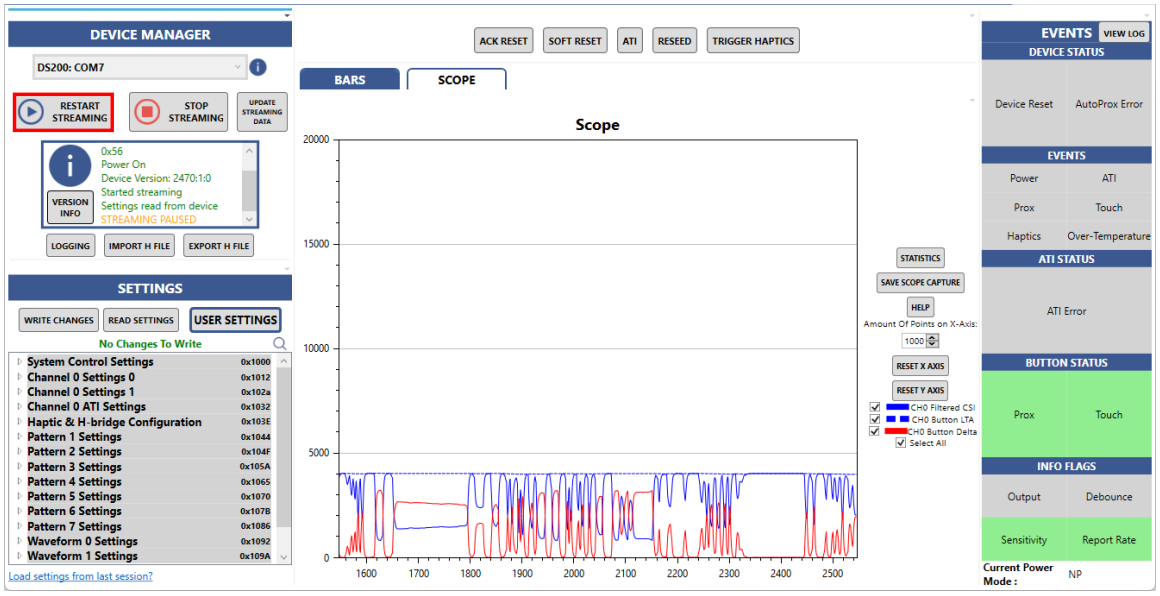


Figure 3.3: Pausing Streamed Data

Then click the ‘Save Scope Capture’ button that appears on the right of the scope view, as indicated with a green block in Figure 3.4.

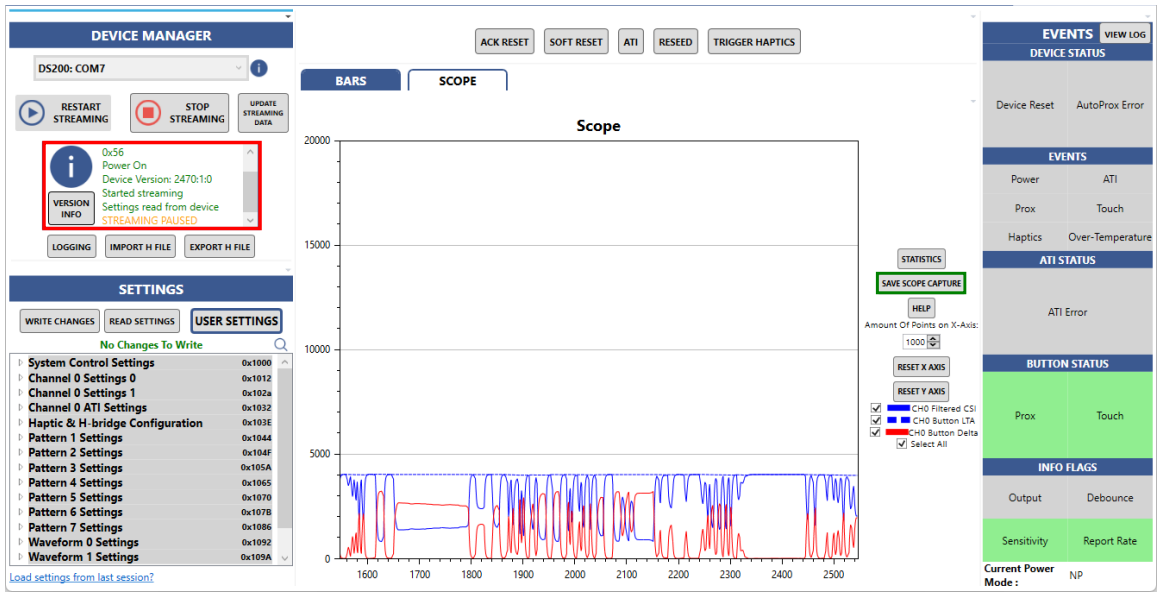


Figure 3.4: Saving Streamed Data

The following window will pop up and prompt the user to select which part of the data should be saved. Select the “Save to CSV" button to save the streamed data.

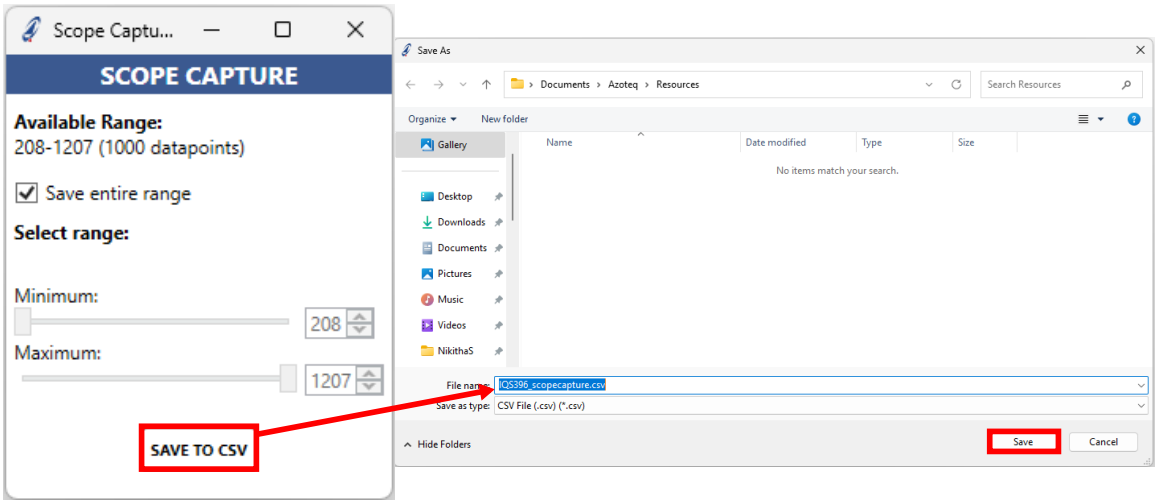


Figure 3.5: Save Streamed Data to CSV File Format

3.2 Data Logging

It may be necessary to save all the above streaming data to a file for debugging or testing purposes. The logging function allows the GUI to save all streaming data from the IQS396 or IQS397 to a CSV file. Click the “Logging” button in the Configuration Tool Manager panel to open the logging window.

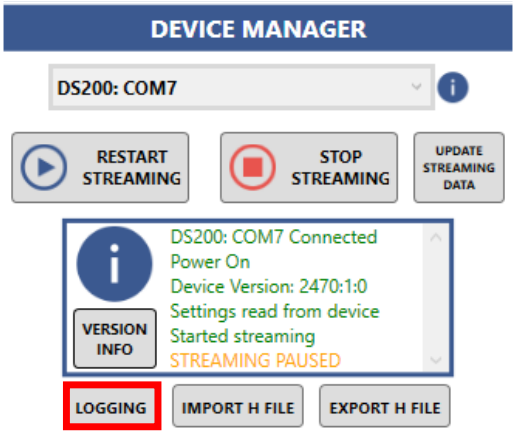


Figure 3.6: Logging Function Using the Configuration Tool Manager

From here, the desired variables from the IQS396 or IQS397 can be enabled or disabled. To start logging, click the “Start Logging” button, and choose the destination of the CSV log file.

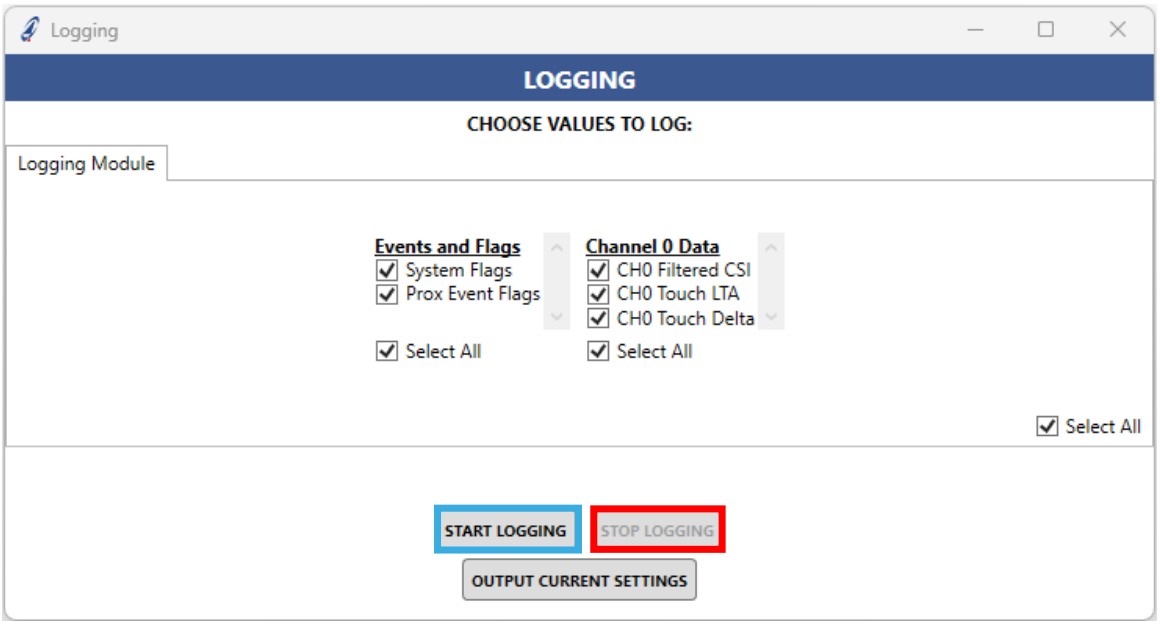


Figure 3.7: Logging Configuration Window

Once the file destination is confirmed, data logging will begin. To stop logging, click the “Stop Logging” button.

3.3 Export Device Configuration to H-File

After configuring the IQS396 or IQS397, you can export the new settings for safekeeping, sharing, or future use on the same or another device. The settings are exported as a *.h*-header file using the “Export H File" button.

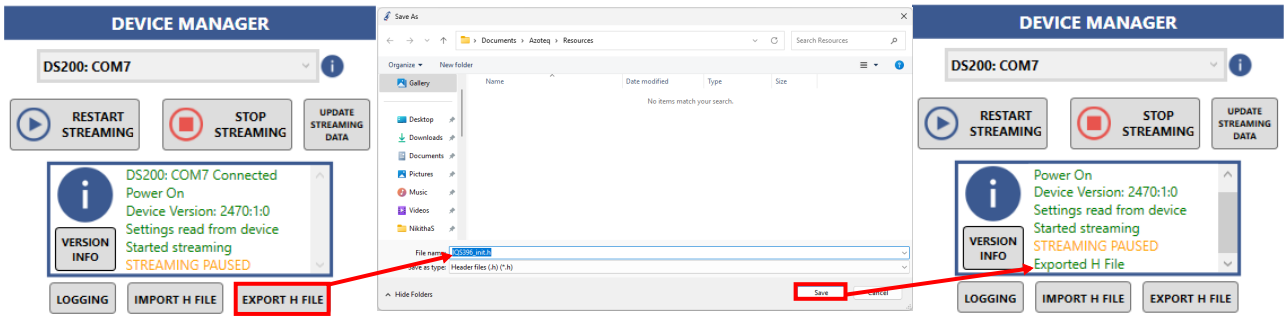


Figure 3.8: Exporting a Defined Configuration

3.4 Import Preconfigured H-File

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 and loaded onto the IQS396 or IQS397 using the “Import H File" button.

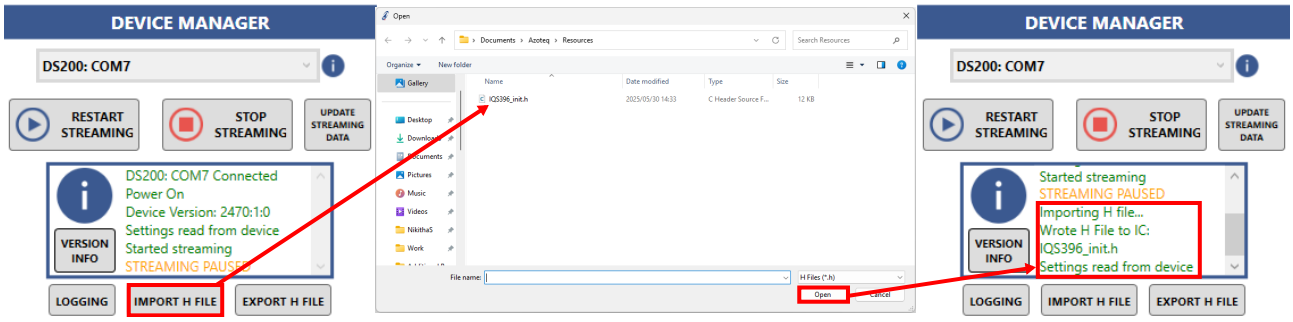


Figure 3.9: Importing a Predefined Configuration

3.5 Command Buttons

At the top centre of the GUI is a row of buttons that execute commonly-used commands.

Figure 3.10: Command Buttons

3.5.1 Acknowledge Reset

The “Ack Reset” button clears the IQS396 and IQS397’s reset flags by writing the **Acknowledge Reset** bit to the IC. This should be the first step after powering on any Azoteq IQS-device. On start-up, the IC will set its reset flag to indicate that a reset event has occurred. The GUI will show that a reset has occurred by changing the Ack Reset button colour to red.

3.5.2 Soft Reset

The “Soft Reset” button issues a command to perform a soft reset. This can be used to clear any configured settings back to their default values.

3.5.3 ATI

The “ATI” button writes the **Re-ATI** command to the IQS396 or IQS397. The ATI routine is a calibration algorithm on the IC that will recalibrate the sensor to the target or reference counts.

Once ATI is complete, the GUI reads all the device settings to update any parameters that the ATI routine may have changed.

3.5.4 Reseed

The “Reseed” command can be used to update the LTA CSI of the ProxFusion channel by setting it equal to the filtered CSI. Note that the Reseed command may trigger an ATI routine if the resulting LTA CSI is significantly different from the target.

3.5.5 Trigger Haptics

The “Trigger Haptics” button issues a command to the IQS396 and IQS397 to run the haptics motor or linear resonant actuator (LRA).

3.6 Events

The panel on the right-hand side of the GUI shows the current event flags that are set on the IC, as shown in Figure 3.11. These indicators are read from the IQS396 and IQS397's status registers.

The conditions for each event to trigger are described in the device datasheet.

3.6.1 System Status

The following events are read from the *System Status* register.

- **Device and ATI Status**:
  - **Device Reset**: A reset event has occurred, and all settings have been reset to defaults.
  - **AutoProx Error**: The ultra low power lower and/or upper trip limit check has failed.
  - **ATI Error**: The device failed to calibrate the channel correctly.
- **Button Status**: These flags indicate the proximity and touch status of the channel, as well as debouncing status.
- **Current Power Mode**: Indicates the current power mode of the device.
- **Events**:
  - **Power**: The power mode has recently changed.
  - **ATI**: An ATI event occurred, and some calibration values may have been updated.
  - **Prox**: The proximity state of the channel has changed.
  - **Touch**: The touch state of the channel has changed.
  - **Haptics**: A haptic event occurred, and the LRA was triggered.
  - **Over-temperature**: The over-temperature trip threshold has been exceeded.

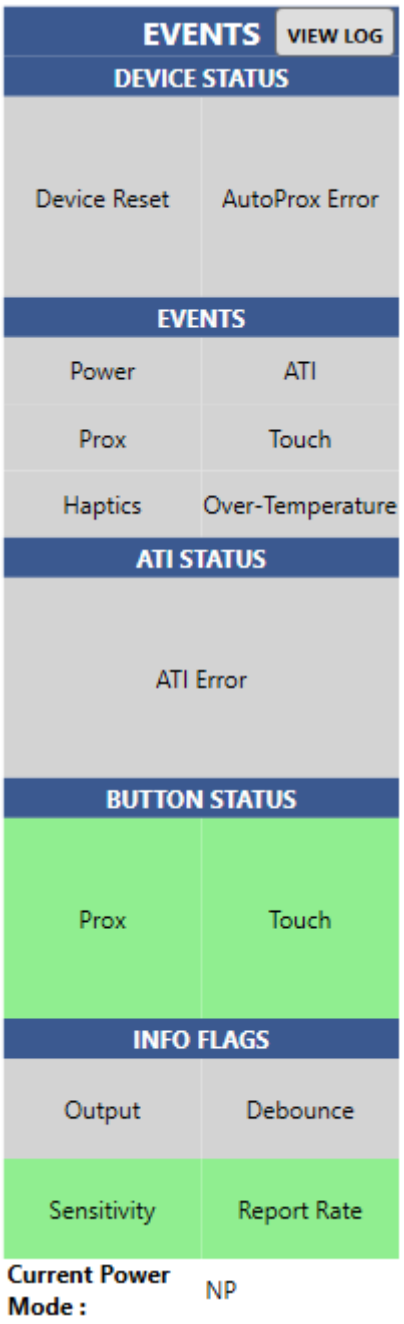


Figure 3.11: Events Panel

4 Device Setup

This section explains some of the basic channel settings, system settings and commands that are specific to the inductive and/or capacitive sensing option of the IQS396 and IQS397. The settings described in Sections 4.1 - 4.4 can be accessed using the “User Settings” button shown in Figure 4.1 below.

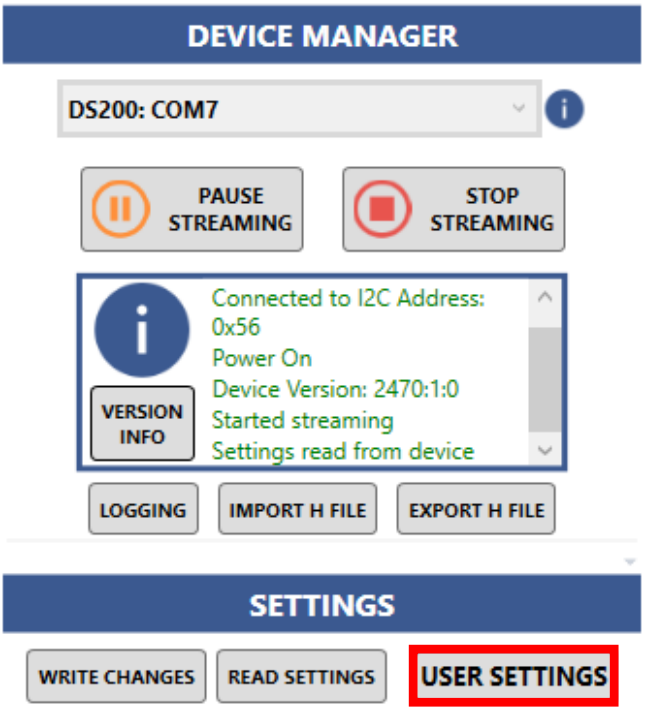


Figure 4.1: User Settings Button

When the “User Settings” button is clicked, a pop-up window will appear with four tabs. The four tabs include system settings, sensor settings, user interface settings and haptics settings. The details of each of the four tabs are provided in Sections 4.1 - 4.4, respectively.

4.1 System Settings

The “Setting Settings” tab, shown in Figure 4.2 below, can be used to configure general settings, such as the device interface and power mode selection. Furthermore, the system timing settings can also be configured, including the report rate, I²C transaction and power mode timeout, and the watchdog and ultra-low power (ULP) settings.

Event reporting is possible when the I²C interface is enabled and at least one of the event bits is enabled. As shown in Figure 4.2, all event bits are enabled by default.

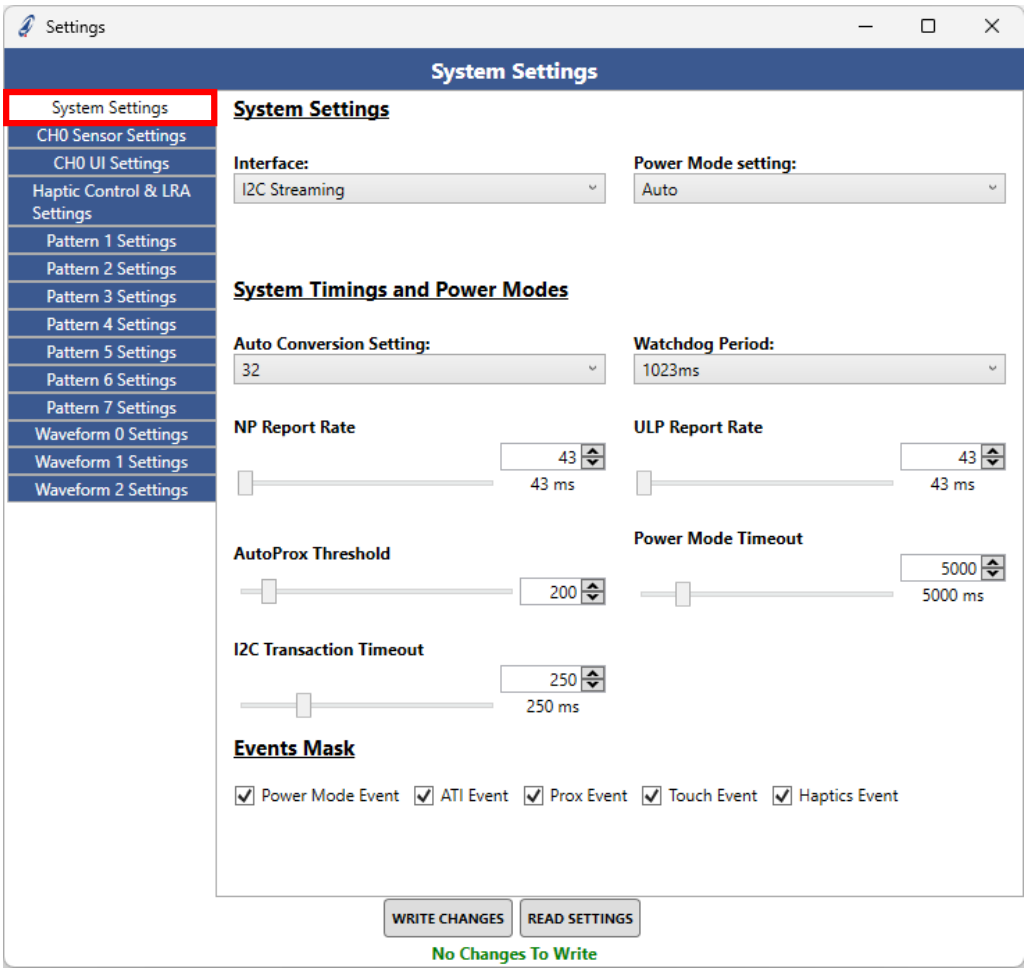


Figure 4.2: System Settings

4.2 Sensor Settings

The “Sensor Settings” tab, shown in Figure 4.3, can be used to configure sensor settings such as sensing mode, conversion frequency and ATI settings. To set up the IQS396 or IQS397 for inductive sensing:

- Select mutual inductance sensing mode
- Set the conversion frequency to 1.75 MHz
- Set the inverse and Tx at FOSC bits
- Set the ATI base and target values according to the sensitivity requirement. Refer to the IQS396 Datasheet or IQS397 Datasheet.

To set up the IQS396 or IQS397 device for self-capacitive sensing:

- Select self-capacitance sensing mode
- Set the conversion frequency to a value of 875 kHz (default) or 438 kHz
- Disable the Tx at FOsc bits
- Set the inverse bit if applicable
- Set the ATI base and target values according to the sensitivity requirement. Refer to the IQS396 Datasheet or IQS397 Datasheet.

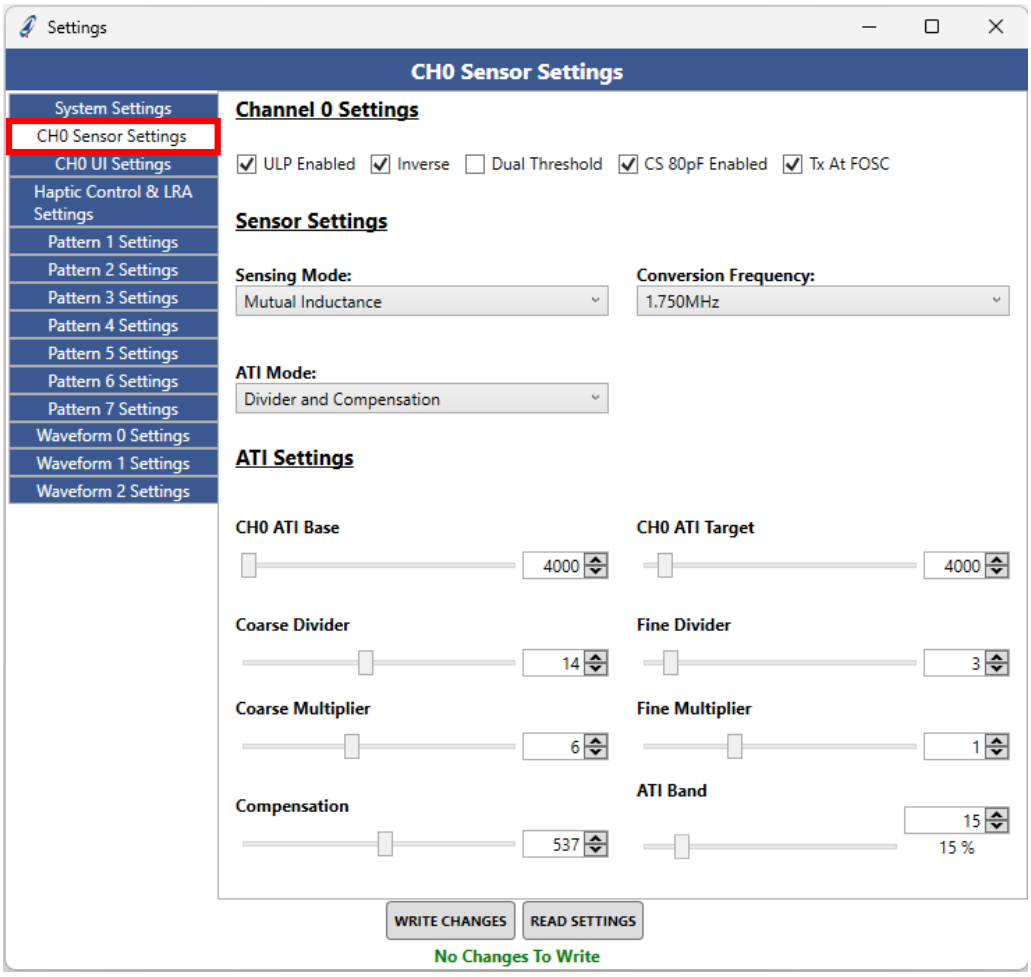


Figure 4.3: Sensor Settings

4.3 User Interface Settings

The “User Interface (UI) Settings” tab can be used to configure the channel event timeout and filter settings as shown in Figure 4.4. Other settings, such as channel proximity and touch thresholds, debounce values, and hysteresis settings, can also be configured as shown in Figure 4.5.

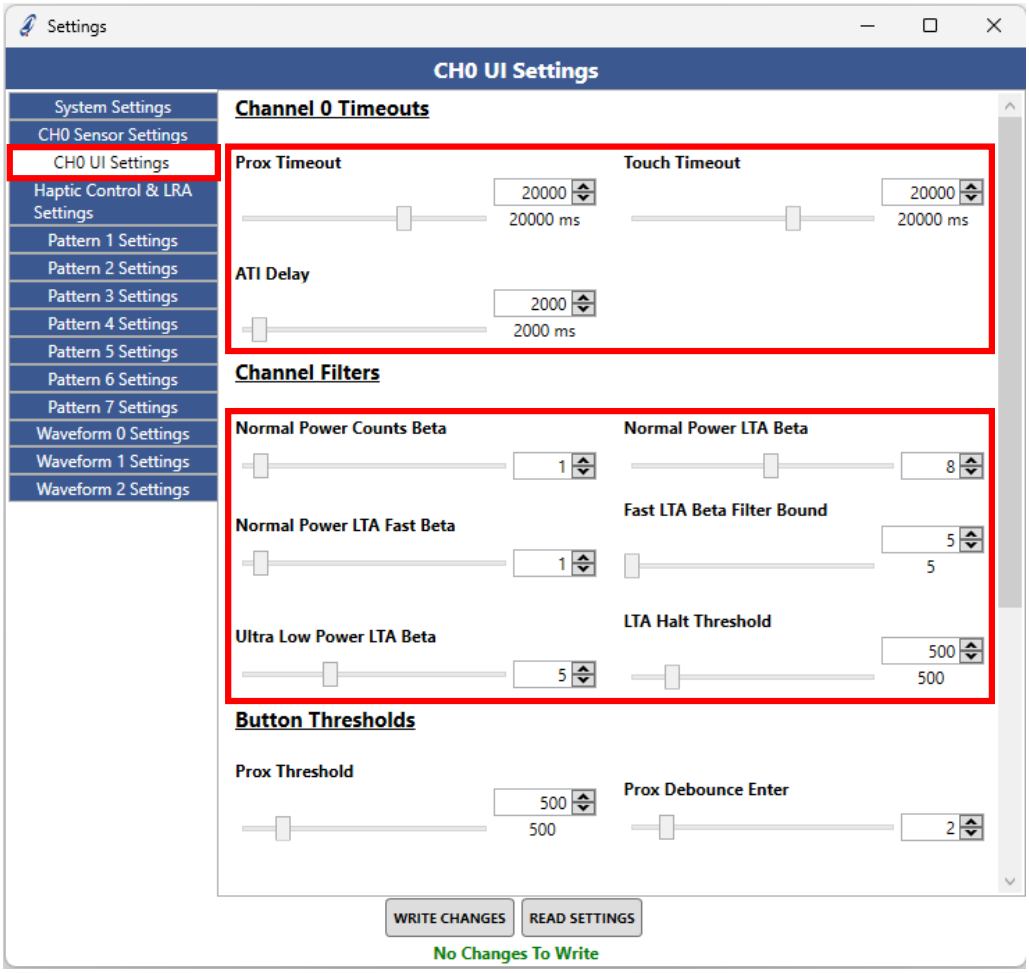


Figure 4.4: Channel 0 Timeout and Filter Settings

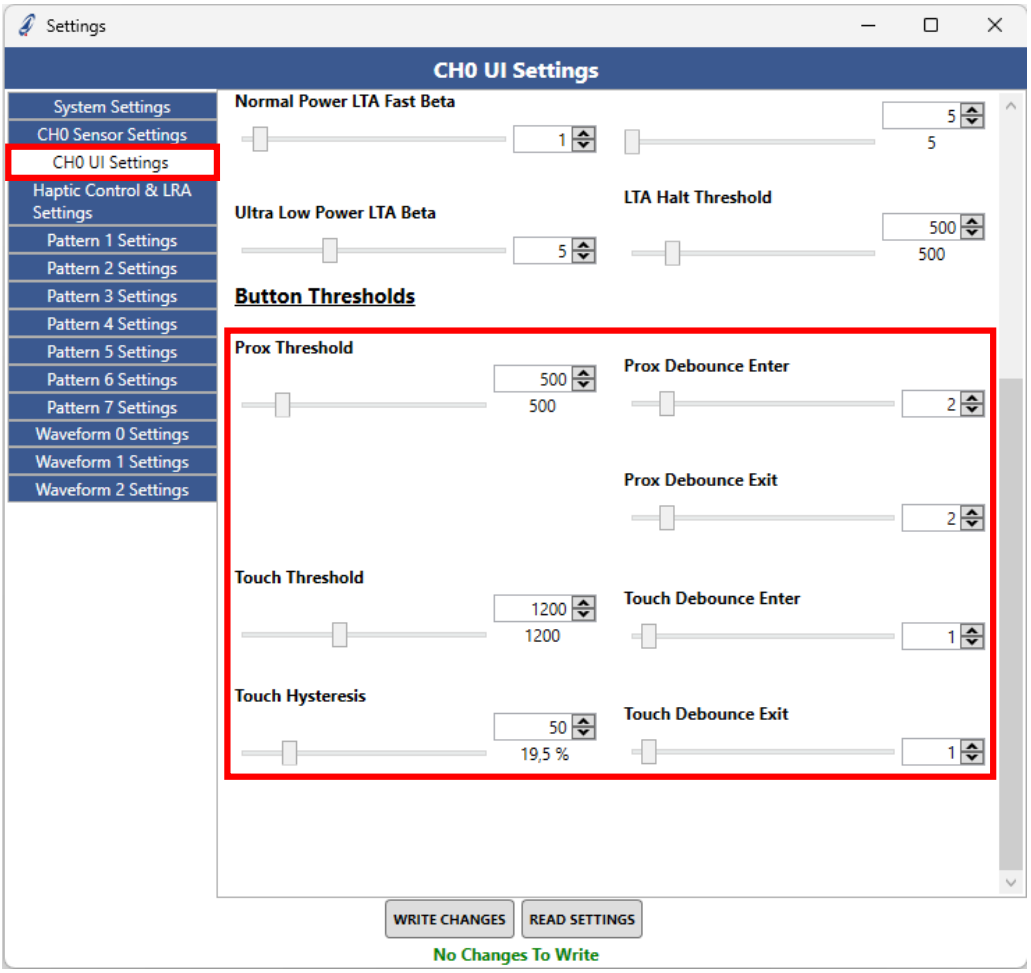


Figure 4.5: Channel 0 Threshold Settings

4.4 Haptic Settings

4.4.1 IQS396 and IQS397 Haptic Settings

The haptics settings tab shown in Figure 4.6 can be used to configure different haptic control and H-bridge settings, as well as different LRA drive settings.

Configurable haptic control and H-bridge settings include the following:

- **Haptics enabled**: When set, the LRA driver will run after a touch event is detected
- **Trigger haptics**: Auto-clear command that runs the LRA driver via an I^2C command
- **Stop haptics**: Auto-clear command that stops the LRA driver
- **Hysteresis**: Enables over-temperature hysteresis
- **Drive strength**: Controls the driving strength of the LRA driver motor

Configurable LRA drive settings include PWM frequency, LRA frequency, half cycles, amplitude, and autoresonance backoff. For more information about the haptic settings, see the IQS396 Datasheet or IQS397 Datasheet.

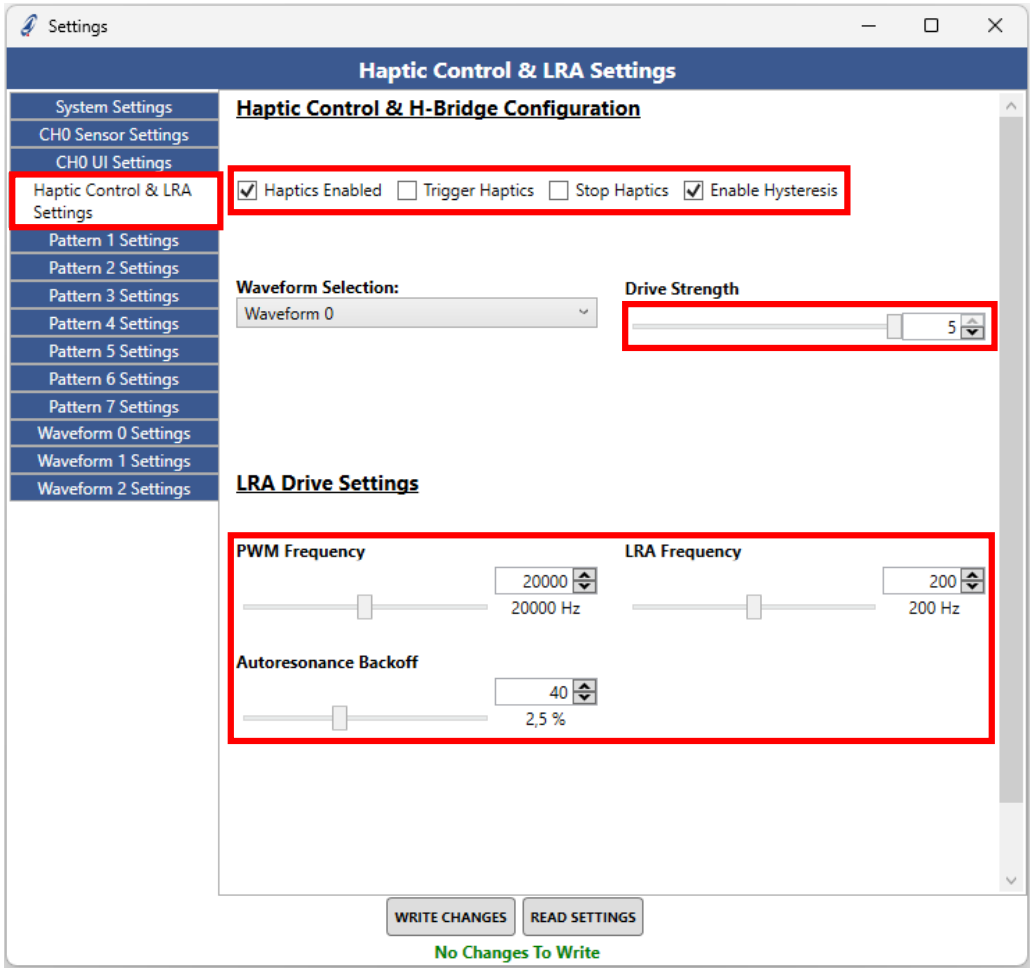


Figure 4.6: Haptics Settings

4.4.2 IQS396 Specific Haptic Settings

The differences between IQS396 and IQS397 was summarised in Table 1.1. The additional settings in the IQS396 that are not present in the IQS397 include multiple patterns and waveform settings. The IQS396 supports multiple patterns as shown in Figure 4.7 and Figure 4.8. The pattern settings include autoresonance, pattern invert logic and number of segments as shown in Figure 4.7.

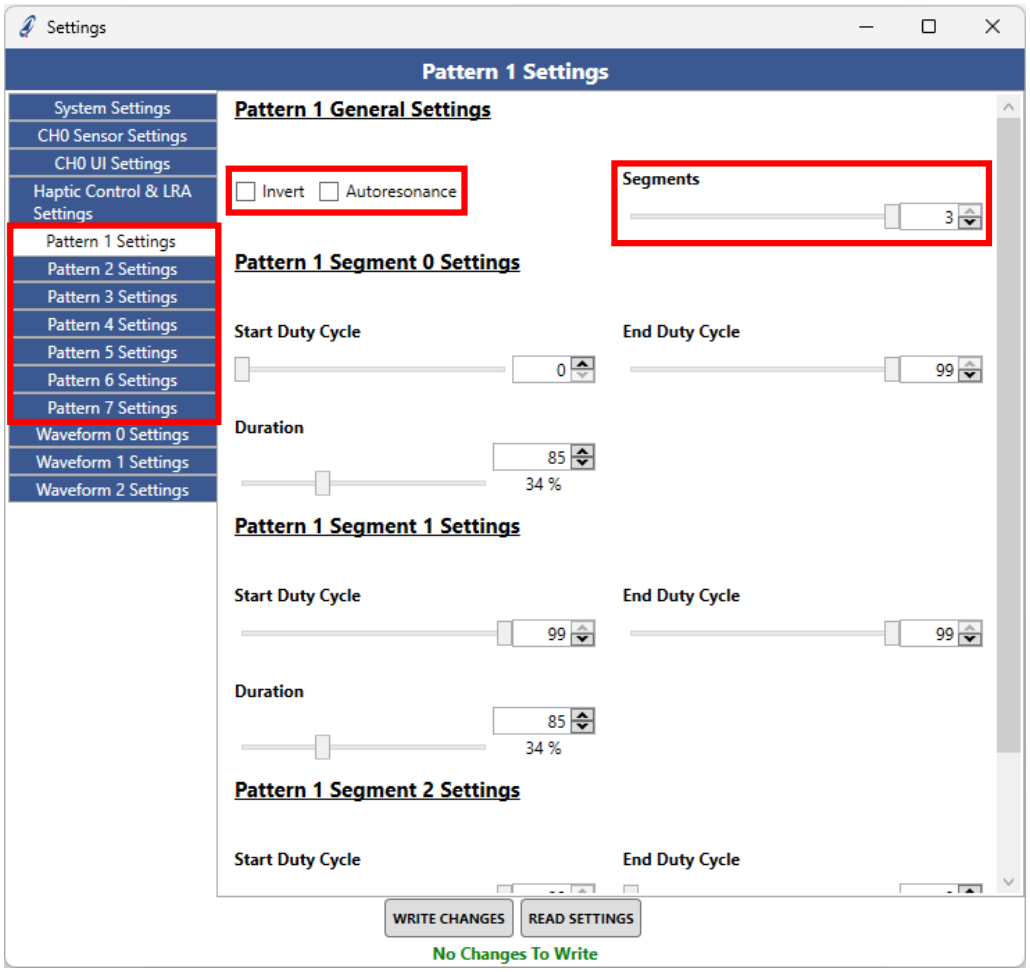


Figure 4.7: Haptic Pattern Settings 0

Other pattern settings include segment start duration, segment end duty cycle, and segment duration, as shown in Figure 4.8.

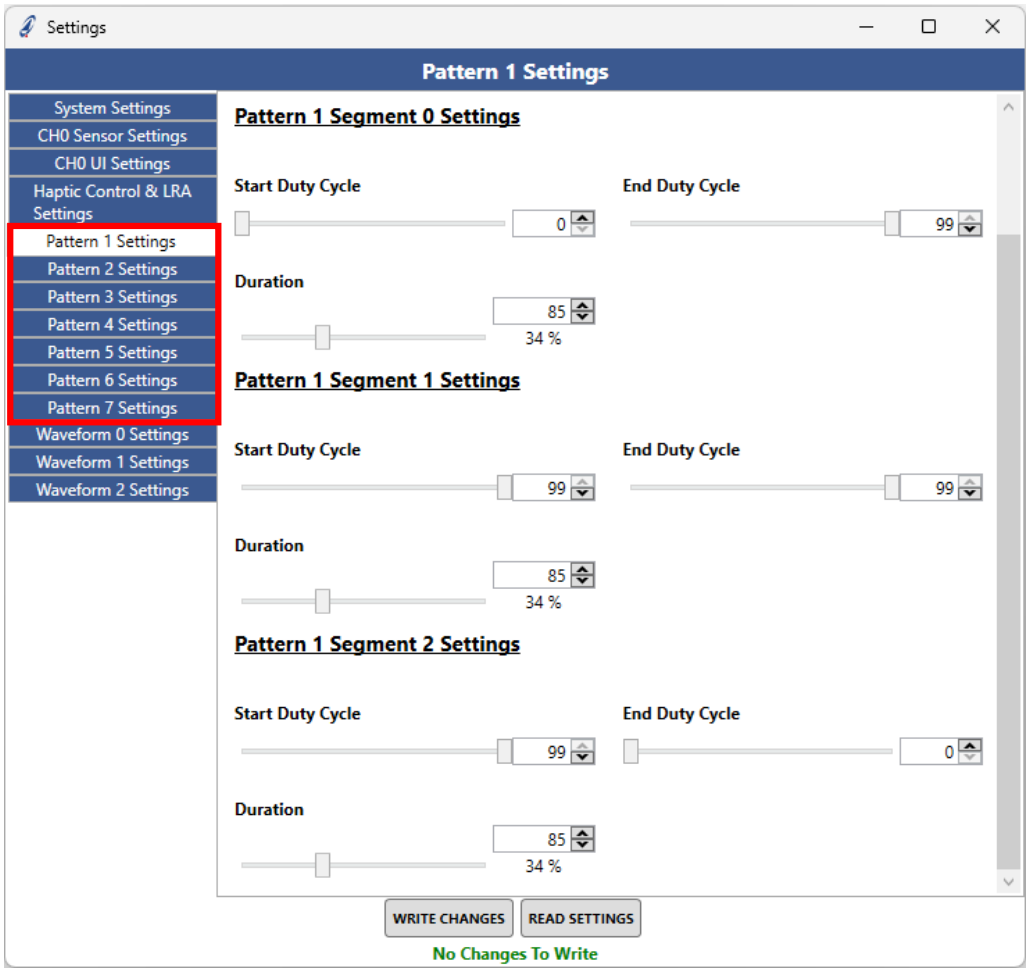


Figure 4.8: Haptic Pattern Settings 1

The IQS396 supports multiple waveforms as shown in Figure 4.9. The waveform settings include stage pattern selection and stage half cycles.

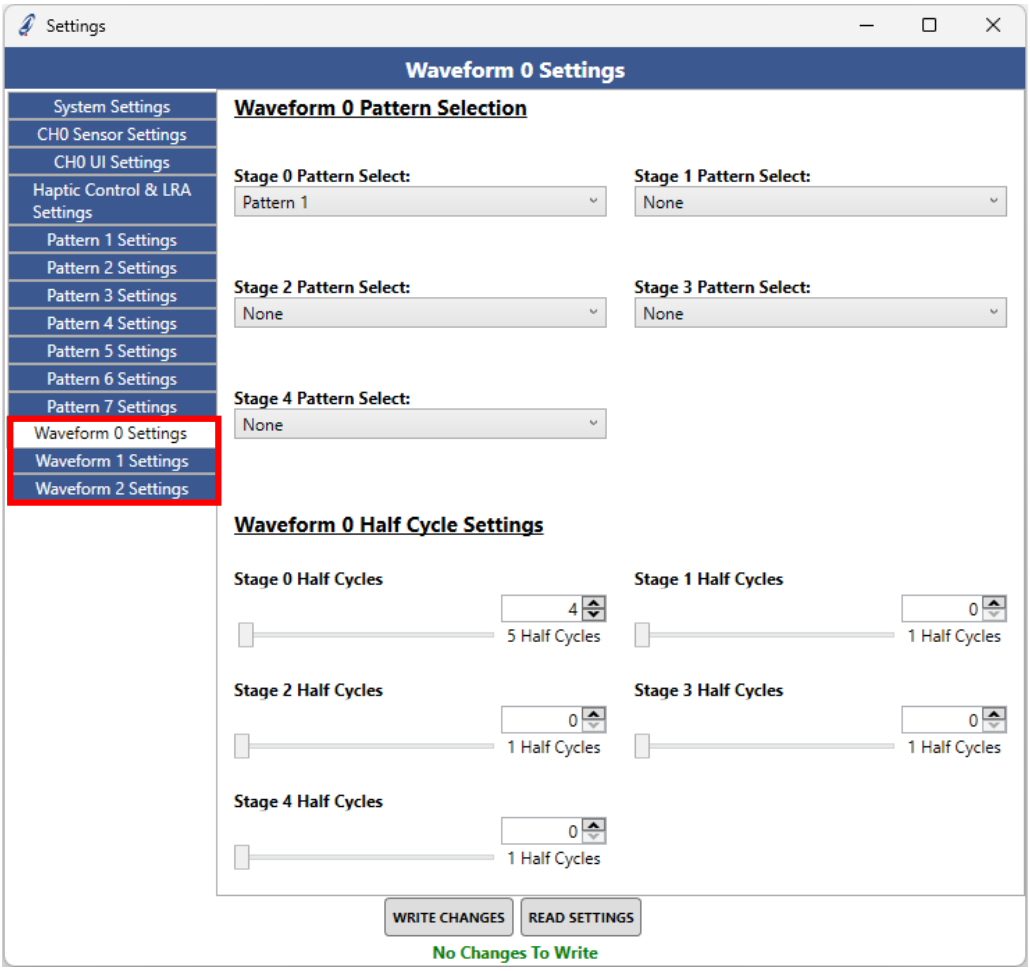


Figure 4.9: Haptic Waveform Settings

5 Reference Design

5.1 IQS396EV02 and IQS397EV02

5.1.1 Self-Capacitive Module

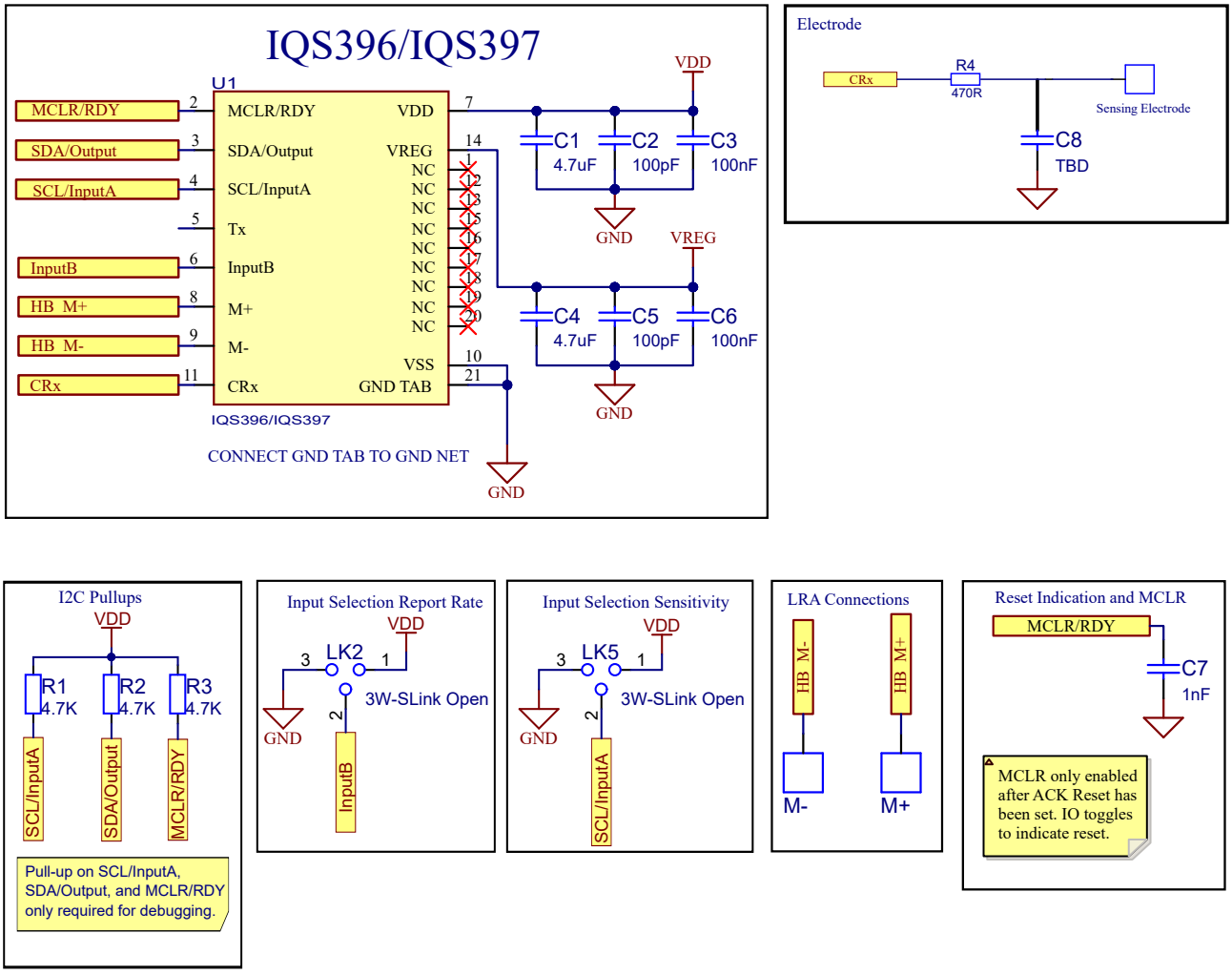


Figure 5.1: IQS396 and IQS397 Self-capacitive Sensing Reference Schematic

5.1.2 Inductive Sensing Module

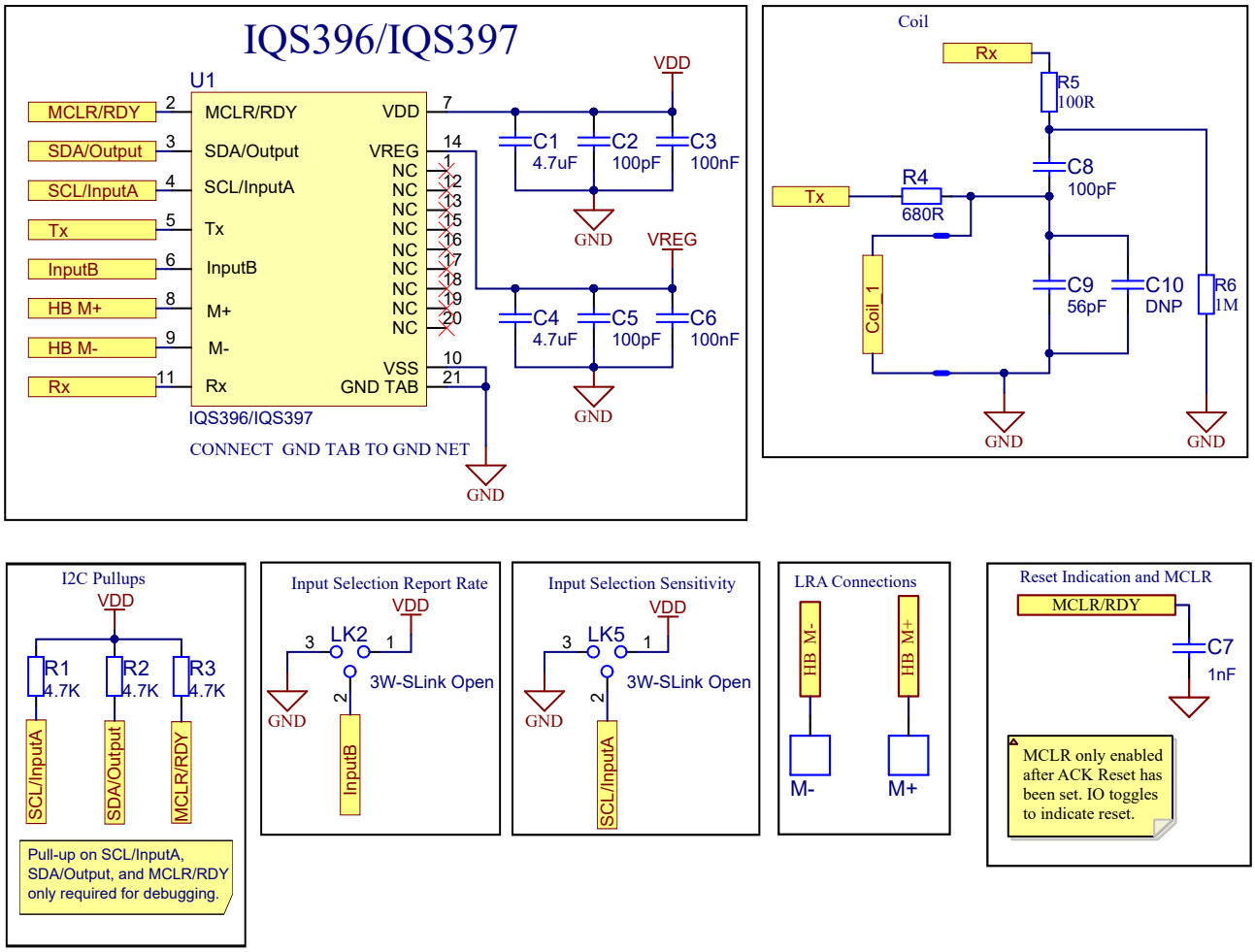


Figure 5.2: IQS396 and IQS397 Inductive Sensing Reference Schematic

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