IQS269A Inductive Sensing Quickstart Guide

Contents

1 Overview

The IQS269A device is capable of inductive sensing in both self and mutual inductance modes, with both these modes requiring the biased configuration for proper operation.Figure 1 and Figure 2 show the channel configuration for the biased self inductance and biased mutual inductance respectively. In self inductance mode a channel uses a single coil for both the excitation and sensing. In the mutual inductance mode each channel has a sensing Rx coil that is mutually coupled to a dedicated excitation Tx coil.

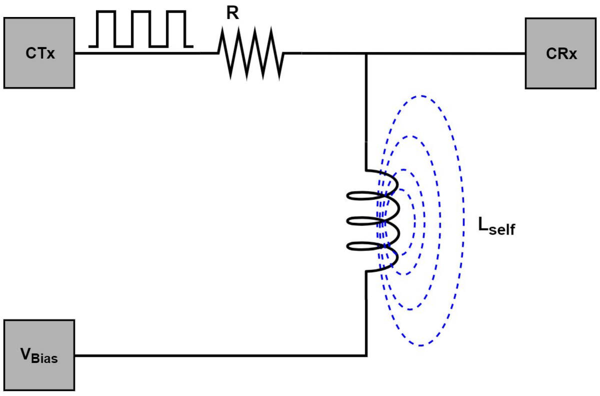


Figure 1: Biased self inductance channel

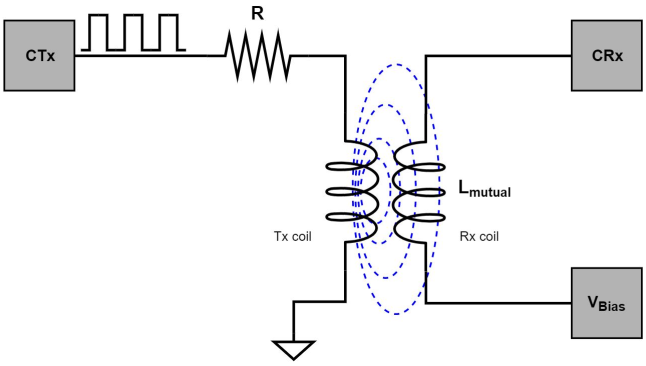


Figure 2: Biased mutual inductance channel

The device has a total of 8 CX pins that can be configured as either excitation pins (CTx) or sensing pins (CRx), with the exception of pin CX1 that is set to the bias voltage in inductive sensing mode. Table 1 shows the possible pin assignments of each of the CX pins.

Table 1: IQS269A CX pin assignment in inductive sensing mode

CX pin	CTx	CRx
CX0	No	Yes
CX1	N/A (1)	N/A (1)
CX2	Yes	Yes
CX3	Yes	Yes
CX4	Yes	Yes
CX5	Yes	Yes
CX6	Yes	Yes
CX7	Yes	Yes

The number of available inductive sensor channels that can be used depends on the inductive sensing mode used. Table 2 shows the available channels for the different sensor modes.

Table 2: IQS269A sensors capabilities for biased configuration

Sensing Mode	Available Channels	Number of CTx pins	Number of CRx pins	Bias pin (CX1)	Total pins required
Mutual Inductance (Biased)	6[(2)]	1	6	Yes	8
Self Inductance (Biased)	3	3	3	Yes	7

For mutual inductance mode with multiple RX sensors, the change in inductance of one sensor by a metal target affects the inductance value of the other RX sensors since all the coils are mutual coupled to the same EM field. Due to the coupling, proximity events over a given sensor should be registered as a relative change in the inductance. For the self inductance mode, the sensors are not coupled and thus a proximity event over a sensor can be registered as the absolute change in inductance.

Design choice between mutual and self mode is primarily dependant on the inductive sensing application. Multiple sensors in the self inductance mode should be used for applications that require absolute readings. Such applications include, encoded event triggers that require a given high-low sequence across the sensors to register a particular event. Multiple sensors in the mutual inductance mode should be used for applications that do not require absolute readings. Such applications include, linear position sliders that indicate the position of a metal target over multiple sensors.

2 Design procedure

- Depending on the inductive sensing application, select either the mutual or the self inductance sensing mode. Refer to Table 2 for the available sensor channels in each mode.
- Determine maximum sensing distance h and design sensor coils with smallest outer diameter D_{out} such that $D_{out} \geq 2h$.
- Select number of turns on each coil such that each coil has the recommended inductance value of at least 0.5 µH. Sensing can be achieved with smaller inductance values, however careful tuning of the tank circuit and device setting is required. A larger inductance value has little significance on the sensing range but provides better noise performance.
- Implement parallel LC tank circuit with resonant frequency f_{res}.

$$f_{res} = \frac{1}{2\pi\sqrt{LC}} \tag{1}$$

  For the mutual inductance mode, the LC tank can either be implemented on only the Tx coil or on both the Tx and Rx coils for greater sensitivity.

- Select capacitor value C such that f_{res} and the coil excitation frequency f_{tx} satisfy the response condition

$$f_{res} \geq f_{tx} \tag{2}$$

[1]CRX1 pin is configured as the bias voltage in inductive sensing mode
[2]7 channels if CTx signal is provided externally (E.g. PWM from an MCU)

3 Self inductance mode

Self inductance mode for the IQS269A requires the biased sensing configuration, where pin CRX1 provides the bias voltage. Each sensor channel has a CTx pin and a corresponding CRx pin.

3.1 Example schematic diagram

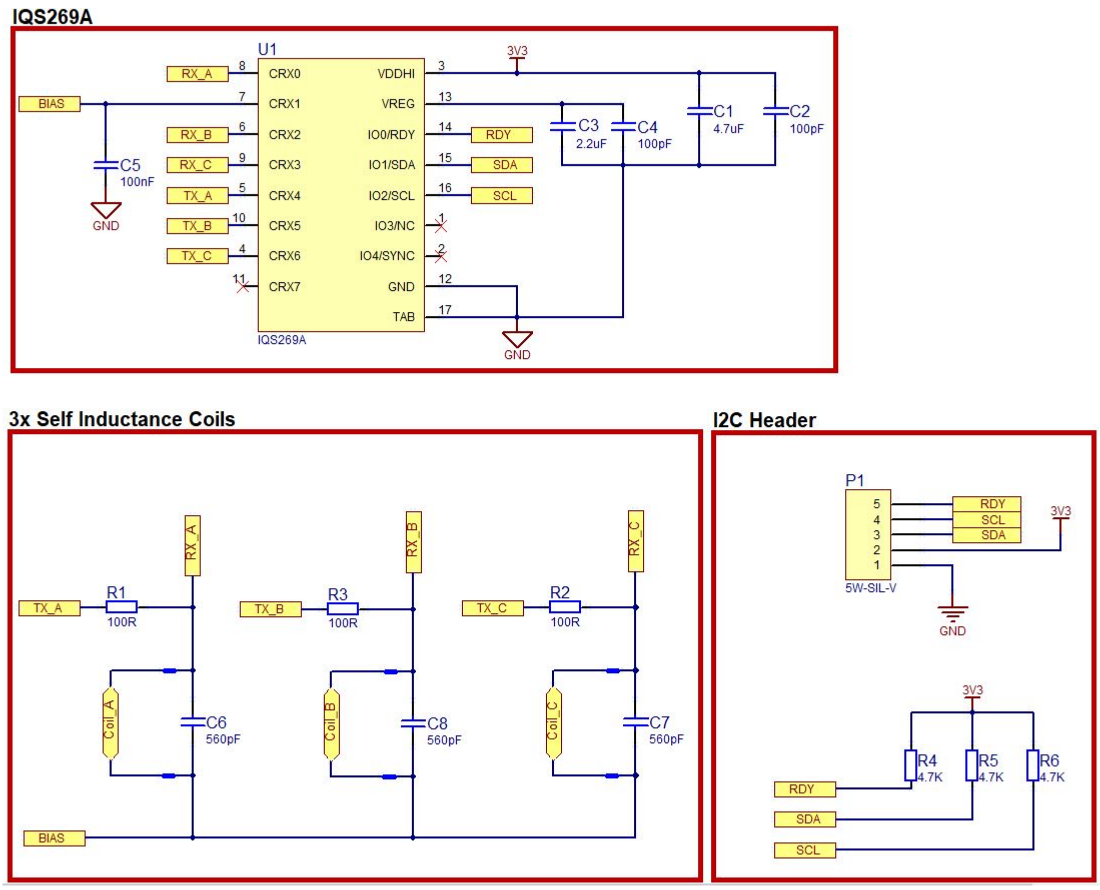


Figure 3: Schematic for 3 self inductance sensors

3.2 Example PCB coil layout

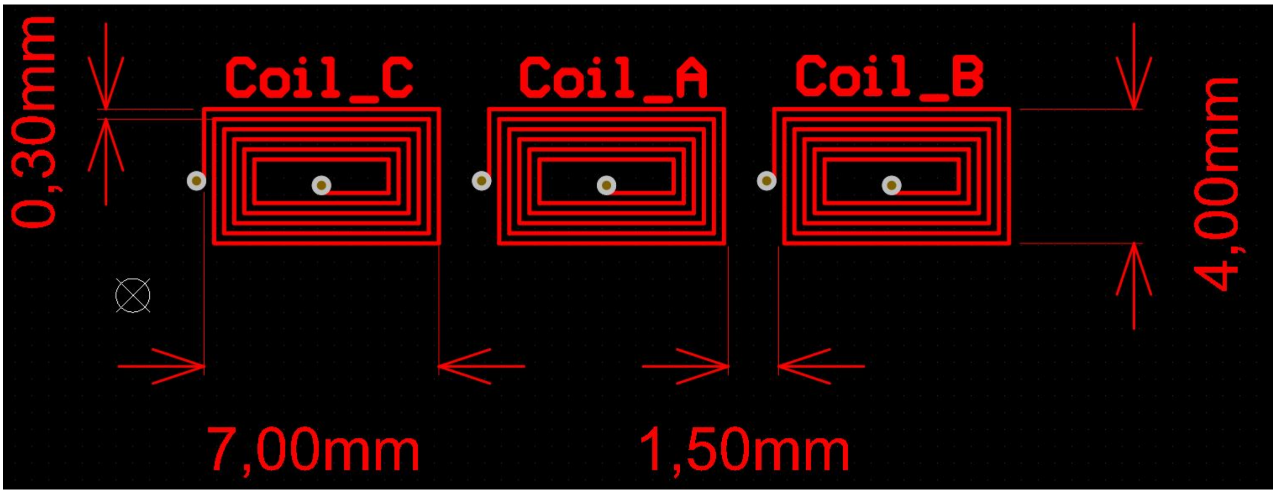


Figure 4: PCB coil dimensions

3.3 LC tank design

The value of parallel capacitor C at each of the coils should be selected to satisfy the response condition $f_{res} \geq f_{tx}$. For this example design f_{tx} is set to 16 MHz. Form Equation (1), the response condition is satisfied when $C \leq 660$ pF.

Due to tolerance in the capacitor value, its good design practice to select a capacitor value that is slightly smaller than the upper limit. This ensures that the response condition is met and the f_{res} is as close as possible to f_{tx} which translates to less signal attenuation. Selecting standard capacitor value of 560 pF $\pm 10\%$ satisfies the response condition.

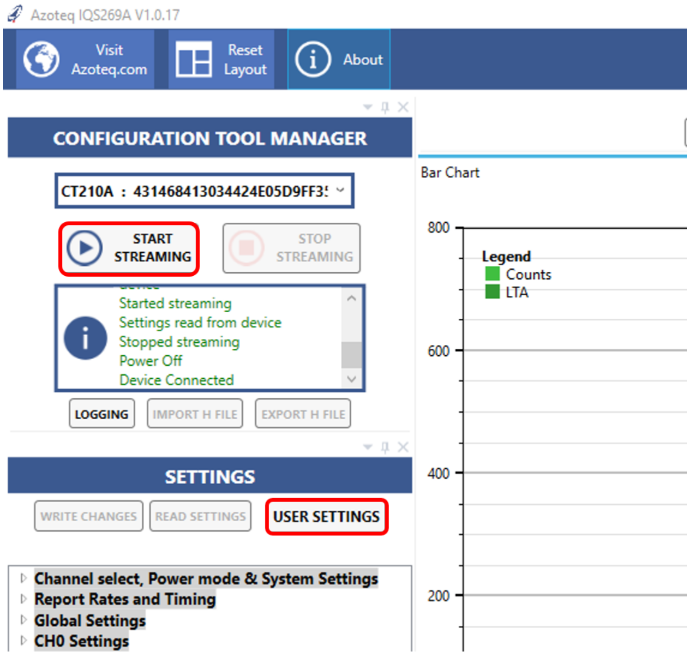
The design and LC tank tuning parameters of the rectangular PCB coils shown in Figure 4 are given in Table 3.

Shape	Rectangle
Length	7.00 mm
Width	4.00 mm
Number of turns	6
Trace width	0.15 mm
Trace spacing	0.15 mm
Measured inductance (L)	0.14 µH
Parallel capacitor (C)	560 pF $\pm 10\%$
f_{res}	18 MHz
f_{tx}	16 MHz

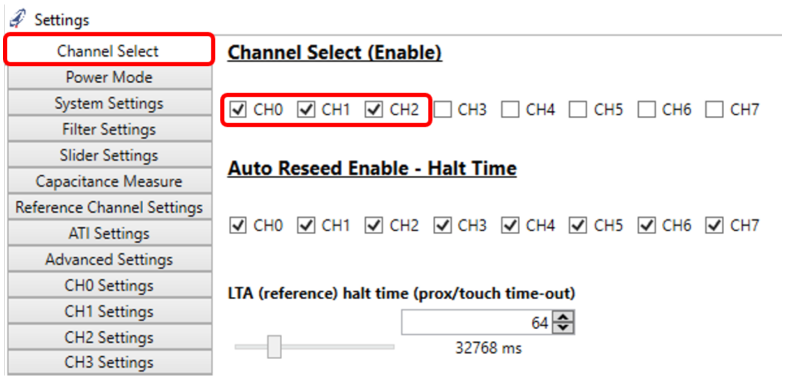
Table 3: Rectangular PCB coil design parameters

3.4 GUI setup

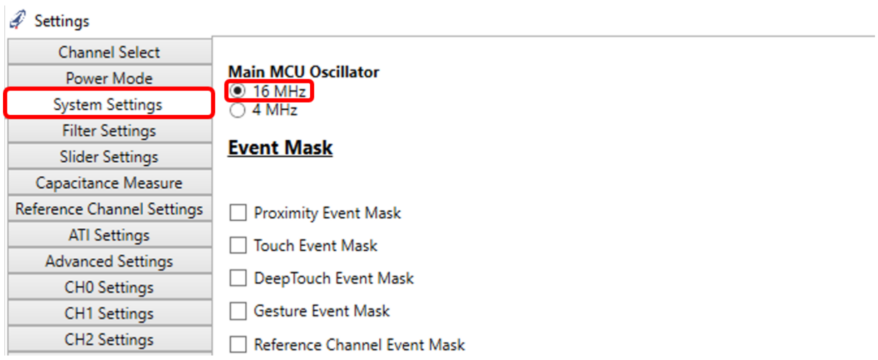
a) Start Streaming and launch user settings window.



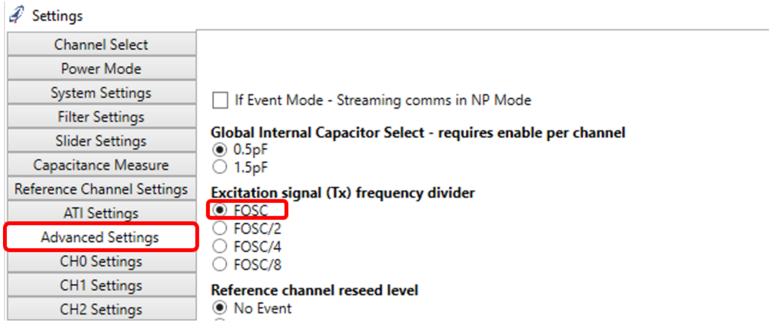
b) Enable CH0, CH1 and CH2



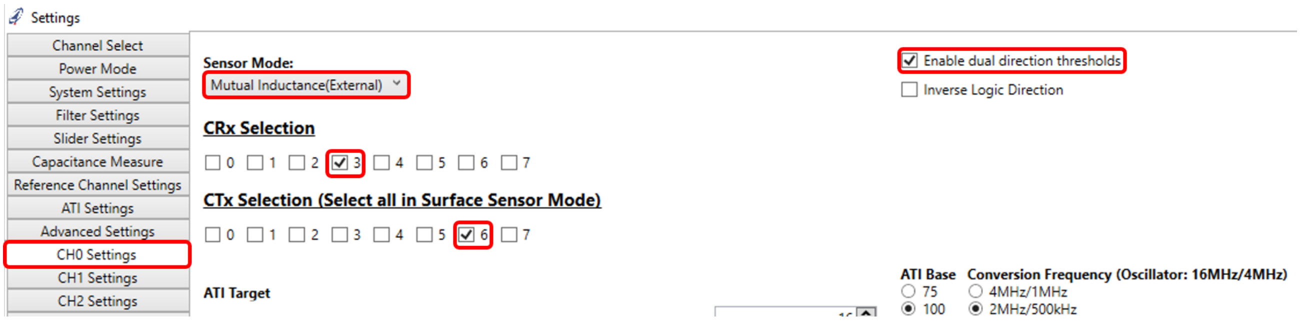
c) Set MCU FOSC to 16 MHz



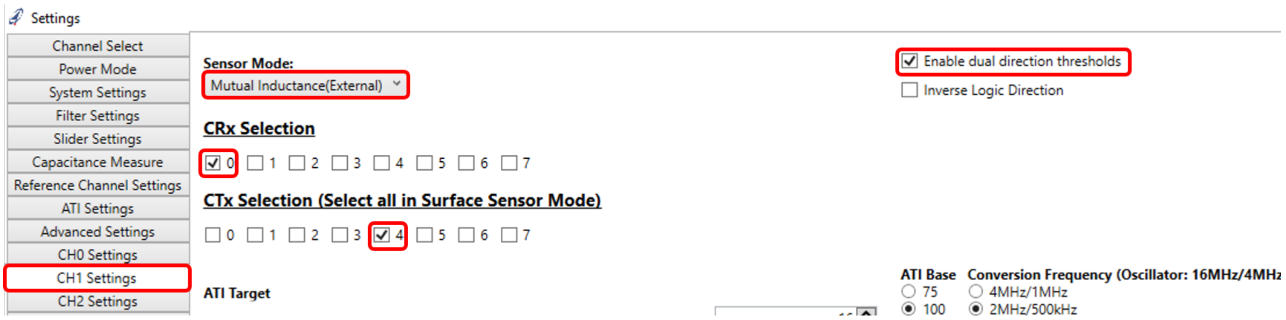
d) Set f_{tx} to 16 MHz



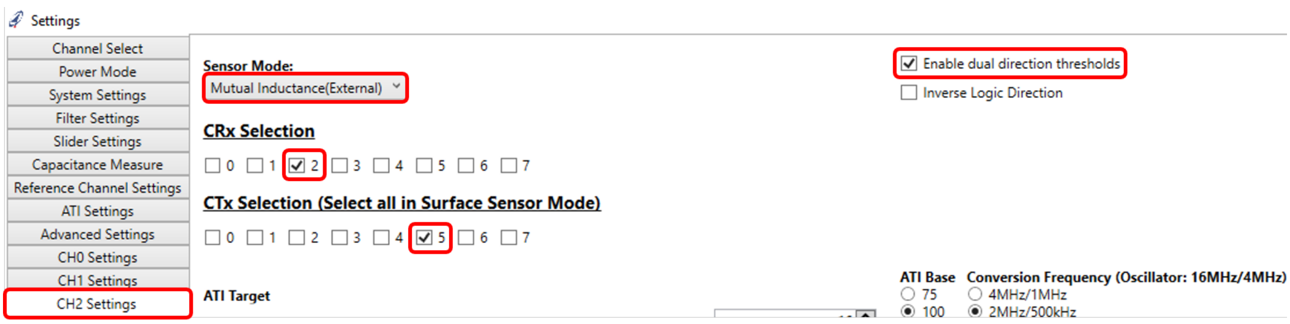
e) Configure CH0



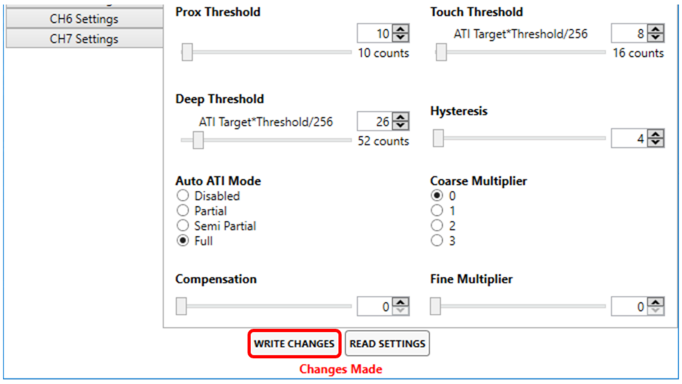
f) Configure CH1



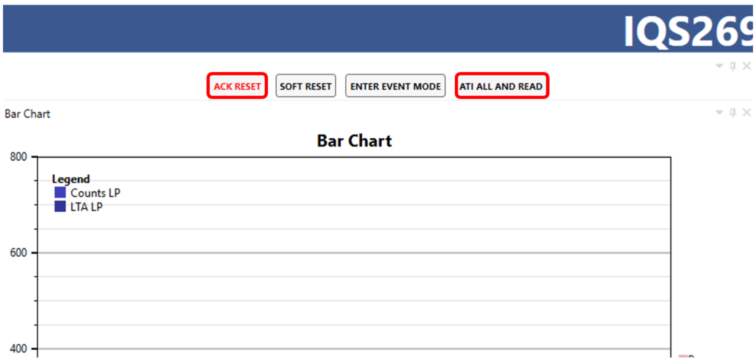
g) Configure CH2



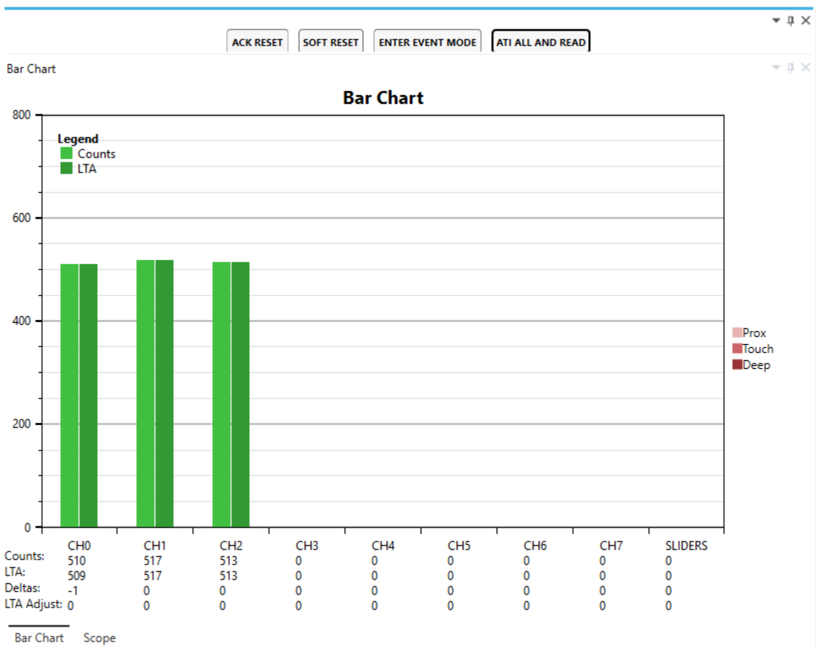
h) Write changes to devices



i) Acknowledge reset and redo ATI.



j) Expected streaming data.



4 Mutual inductance mode

Mutual inductance for the IQS269A requires the biased sensing configuration. In inductance mode the device automatically enables pin CX1 as the bias point.

4.1 Schematic diagram

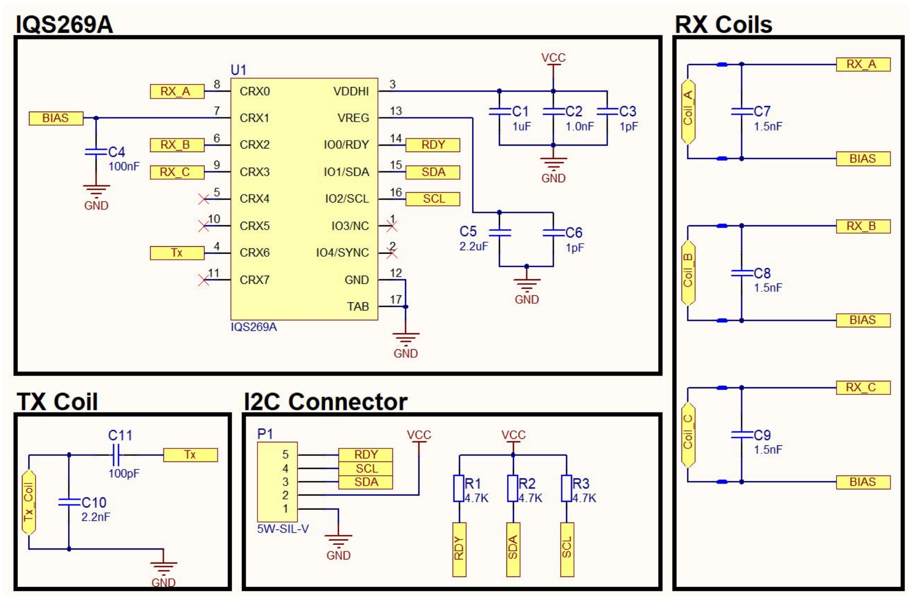


Figure 5: Mutual inductance sensing schematic diagram

4.2 PCB outline

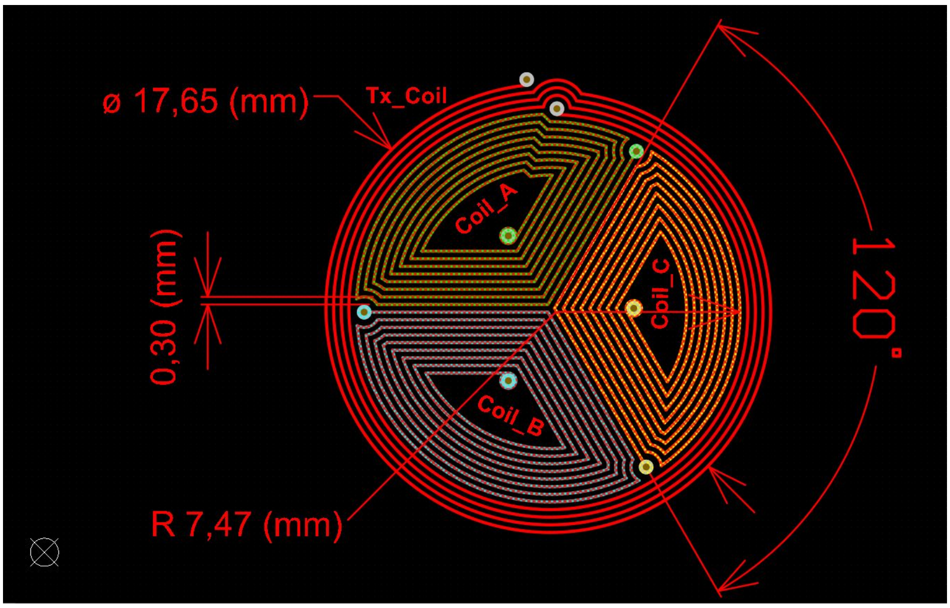


Figure 6: Mutual inductance PCB coil layout

4.3 LC tank design

The same procedure as given in Section 3.3 is followed for calculating the parallel tank capacitor. The C value is chosen such that response condition $f_{res} \geq f_{tx}$ is satisfied. The design and LC tank tuning parameters for the Tx and Rx PCB coils are given in Table 4 and Table 5 respectively.

Table 4: Tx circular shaped PCB coil design parameters

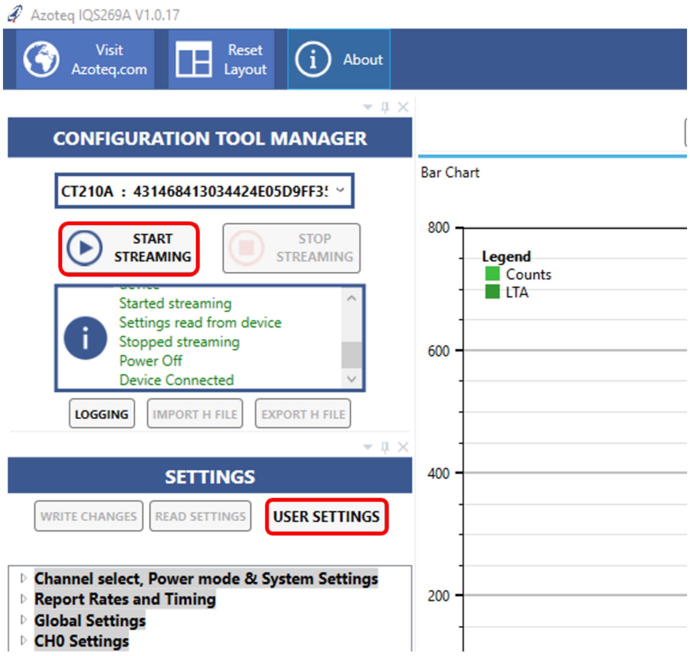
Shape	Circle
Diameter	17.65 mm
Number of turns	4
Trace width	0.15 mm
Trace spacing	0.15 mm
Measured inductance (L)	0.61 µH
Parallel capacitor (C)	2.2 nF ±10%
f_{res}	4.3 MHz
f_{tx}	4 MHz

Table 5: Rx arc shaped PCB coil design parameters

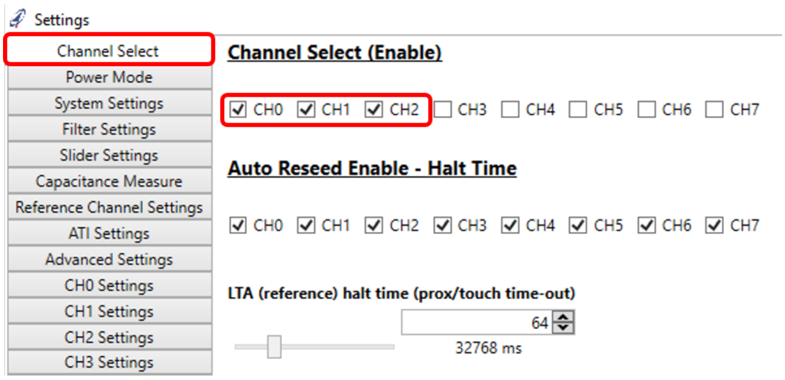
Shape	Arc
Angle	120°
Radius	7.47 mm
Number of turns	9
Trace width	0.15 mm
Trace spacing	0.15 mm
Measured inductance (L)	0.72 µH
Parallel capacitor (C)	1.5 nF ±10%
f_{res}	4.8 MHz
f_{tx}	4 MHz

4.4 GUI setup

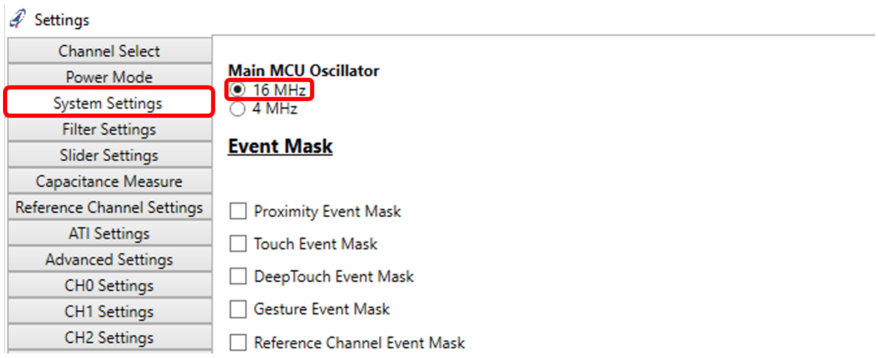
a) Start Streaming and launch user settings window.



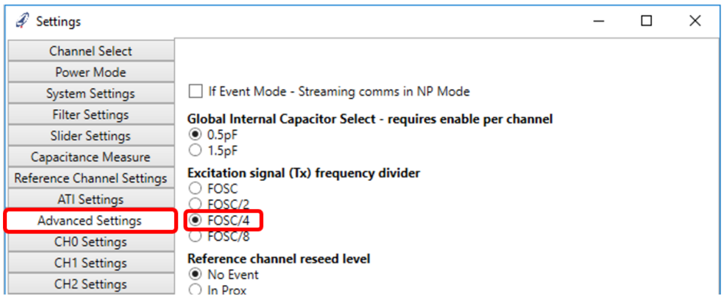
b) Enable CH0, CH1 and CH2



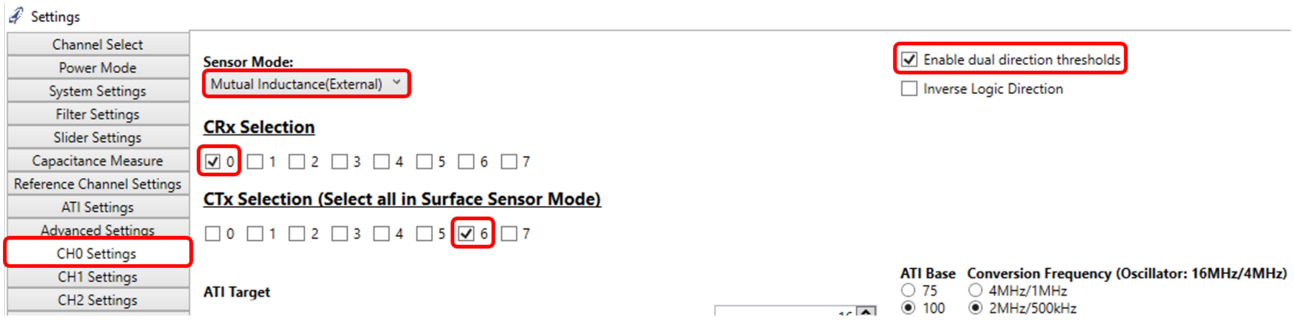
c) Set MCU FOSC to 16 MHz



d) Set f_{tx} to 4 MHz



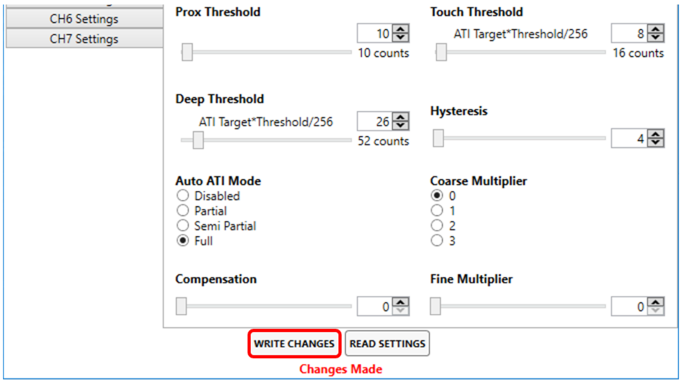
e) Configure CH0



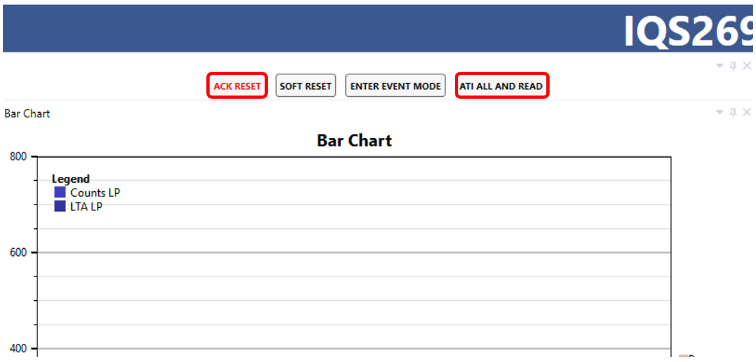
f) Configure CH1

g) Configure CH2

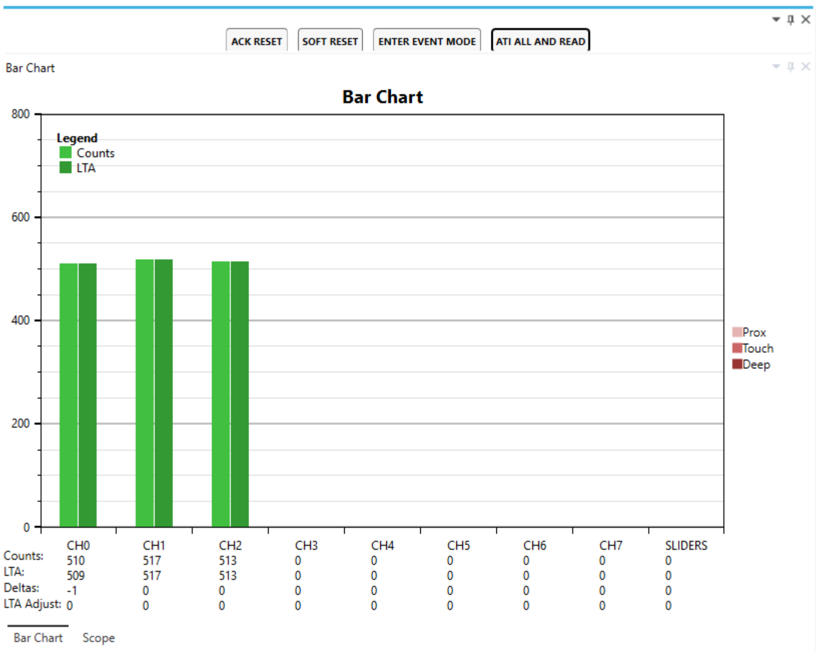
h) Write changes to devices



i) Acknowledge reset and redo ATI.



j) Expected streaming data.



5 Design considerations

5.1 Series resistor vs parallel LC tank

It is always recommended to use the parallel LC tank circuit at the excitation coil. However, a series resistor can help in reducing the amount of EM emissions while still providing a sufficient sensing signal. This is helpful in cases where EMC compliance required.

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The following patents relate to the device or usage of the device: US 8,395,395; US 8,659,306; US 9,209,803; US 9,360,510; US 9,496,793; US 9,709,614; US 9,948,297; EP 2,351,220; EP 2,559,164; EP 2,748,927; EP 2,846,465; HK 1,157,080; SA 2001/2151; SA 2006/05363; SA 2014/01541; SA 2017/02224;

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