AZD087 – IQS5xx-B000 Setup and User Guide

Description of product configuration using provided supporting tools

1 Introduction

The aim of this document is to give a step-by-step guide on how to configure the IQS5xx-B000 project for a custom design application. This document will assist in using the IQS5xx-B000 in the intended manner to obtain a working solution with ease.

A summary of the design process is shown below:

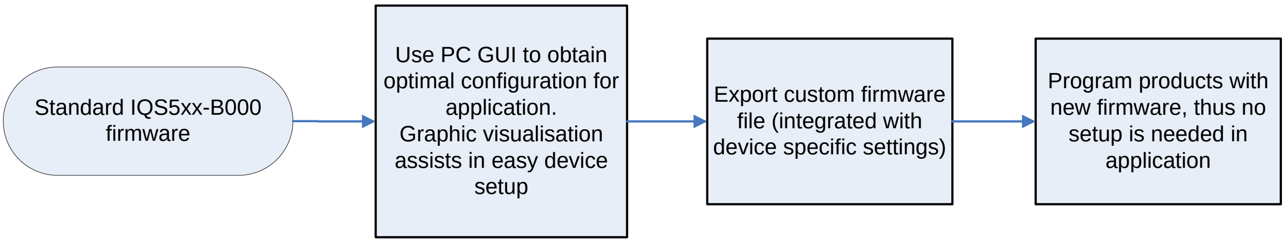

Standard IQS5xx-B000 firmware
Use PC GUI to obtain optimal configuration for application. Graphic visualisation assists in easy device setup
Export custom firmware file (integrated with device specific settings)
Program products with new firmware, thus no setup is needed in application

Figure 1.1 Design process summary

The result of this process is to obtain a custom firmware file which includes the parameters specific for the current application. This simplifies the master controller firmware with no device setup required at run-time; the device is ready to operate faster after power-up, without any intervention.

Since this is a setup guide, please also refer to the IQS5xx-B000 datasheet for specific product details.

2 IQS5xx-B000 GUI

The graphical user interface (GUI) is a powerful support/design tool to simplify the process of configuring the IQS5xx device with the parameters required for optimal performance for customer specific hardware.

The latest GUI can be obtained from the Azoteq website (www.Azoteq.com).

3 Hardware connections

Connect the application hardware power and I^2C lines to the CT210 USB dongle as shown in the table and figure below.

Table 3.1 CT210 I^2C pin-out

IQS5xx Pins	CT210
GND	pin1
VDDHI	pin3
SDA	pin7
SCL	pin9
RDY	pin10

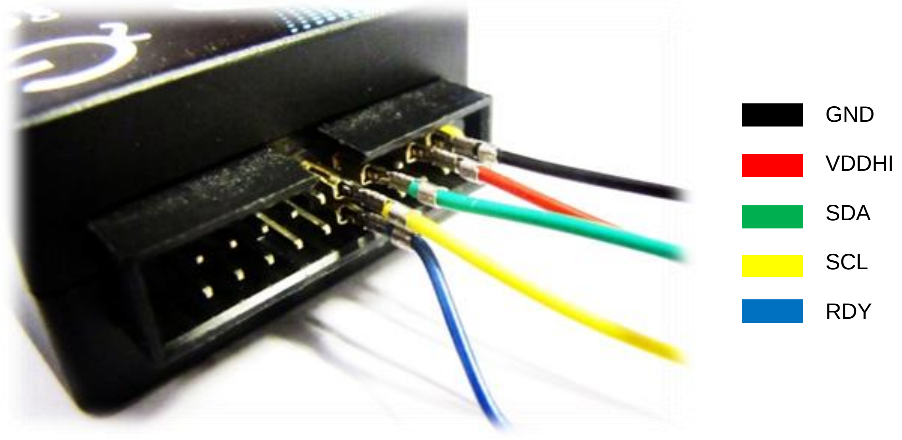


Figure 3.1 CT210 I^2C connections

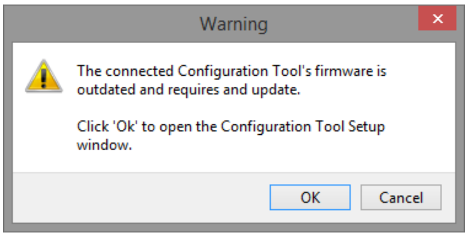
Now connect the USB of the CT210 to the PC.

4 Firmware updating

The IQS5xx-B000 is a firmware upgrade for the IQS5xx-A000 generic trackpad. The device firmware must thus first be updated to the default IQS5xx-B000 firmware base.

4.1 CT210 firmware update

The IQS5xx-B000 implements some features that require the CT210 to have the latest firmware programmed. When the CT210 is connected to the PC, the IQS5xx-B000 GUI will automatically prompt the user with a request that indicates that a CT210 firmware update is required.

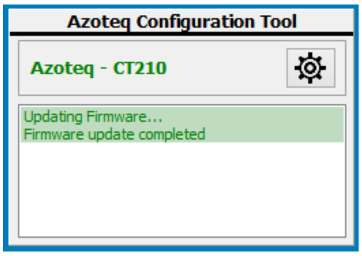


The connected Configuration Tool's firmware is outdated and requires and update.

Click 'Ok' to open the Configuration Tool Setup window.

Figure 4.1 CT210 firmware update request

Press *Ok* to update the firmware on the CT210. On the next window, press the **Update to latest version** button, followed by *Yes* to start the firmware update. When completed, the update window can be closed, and the *Azoteq configuration tool* section at the top-left of the main GUI window should be displayed in green text, as shown below:


Azoteq Configuration Tool

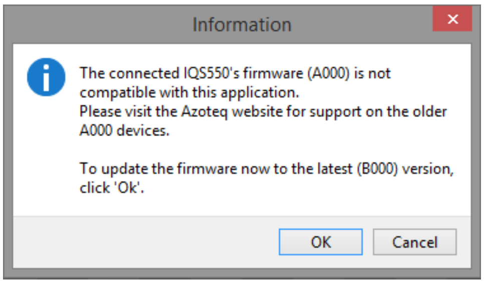
Azoteq - CT210

Updating Firmware...
Firmware update completed

Figure 4.2 CT210 firmware is up to date

4.2 Automatic updating through GUI

With the IQS5xx device connected to the PC GUI as described, open the GUI, and press **Start ▶**. If all of the hardware is correctly connected, the GUI will detect that the B000 firmware is not programmed on the device, and ask if it may be updated, as shown below.



The connected IQS550's firmware (A000) is not compatible with this application.
Please visit the Azoteq website for support on the older A000 devices.

To update the firmware now to the latest (B000) version, click 'Ok'.

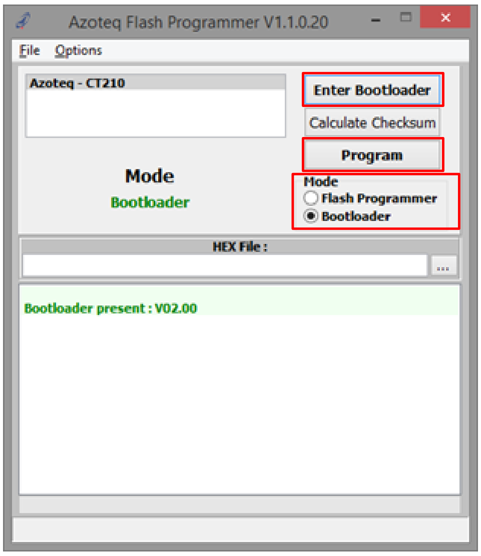
Figure 4.3 Automatic firmware updating through GUI

Click *Ok* to program the device with the latest B000 firmware. This will automatically open the programmer application, load and program the firmware, and then close the application. After this the device is successfully updated to the B000 firmware.

4.3 Manual updating with programmer

Open the 'Azoteq Flash Programmer' application, which would also have automatically installed together with the GUI installation (…\Azoteq\Azoteq Flash Programmer\).

Change the programming mode to *Bootloader*, and then click on *Enter Bootloader* to test the hardware connections, and confirm whether the current firmware has an I^{2}C bootloader available.



Mode
Bootloader

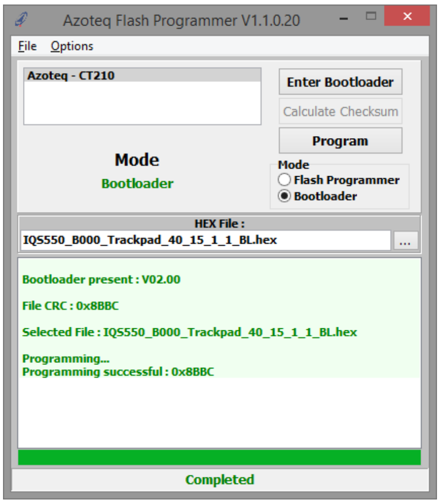
Mode
○ Flash Programmer
● Bootloader

Bootloader present : V02.00

Figure 4.4 Flash programmer and bootloader entry

After confirming communication with the bootloader, load the HEX file to program by clicking on the '…' button and selecting the appropriate file. The latest B000 file for each platform can also be found inside the GUI installation folder (…\Azoteq\Azoteq IQS5XX-B000\IQS5XX Firmware), and press *OK*. Now program this onto the device by pressing *Program*.

If programming is successful, then the window will display as follows:



IQS550_B000_Trackpad_40_15_1_1_BL.hex

```
Bootloader present : V02.00
File CRC : 0x8BBC
Selected File : IQS550_B000_Trackpad_40_15_1_1_BL.hex
Programming...
Programming successful : 0x8BBC
```

Figure 4.5 Successful programming

The IQS5xx device is now programmed and ready to be used with the PC GUI software.

5 Basic device setup

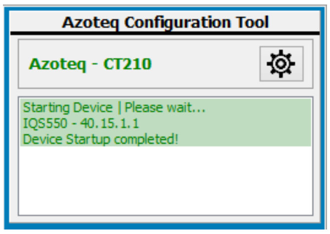
The on-chip parameters need to be configured for the application to operate optimally. Setting up a capacitive sensing device for optimal performance requires a number of parameters to be tuned correctly. However, to get started, a basic setup is easy to achieve after which the settings can be optimised, and more advanced features can be configured.

5.1 Getting started

The number of sensors implemented, and their connections, are configured together with an initial configuration from which to start optimising.

The TPS65 trackpad module is the hardware used as example to be configured in this document.

Start the device by pressing the **Start ▶** button on the main window. Look out for any errors in the top left CT210 window, if all is in order, the configuration section should display as follows:



```
Starting Device | Please wait...
IQS550 - 40.15.1.1
Device Startup completed!
```

Figure 5.1 Successful device connection and start

If this is not successful, make sure the CT210 and IQS5xx device firmware are up to date, as described in previous sections. Also make sure the I^{2}C connections to the device are connected correctly (which should be the case if firmware updating with the bootloader was possible).

The settings are configured from the separate settings window which can be opened from the main window by pressing the Settings ⚙ button. Once any setting is modified, it needs to be sent to the device by pressing the Apply button. To revert back to the settings before the adjustment (if it has not yet been sent), the Undo button can be pressed.

5.2 Total Rx and Tx channel setup

The first step is to select the total number of Rx and Tx channels implemented in the design. The TPS65 module layout is shown in the picture below, and it can be seen that there are 13 Txs configured as columns, and 9 Rxs configured as rows.

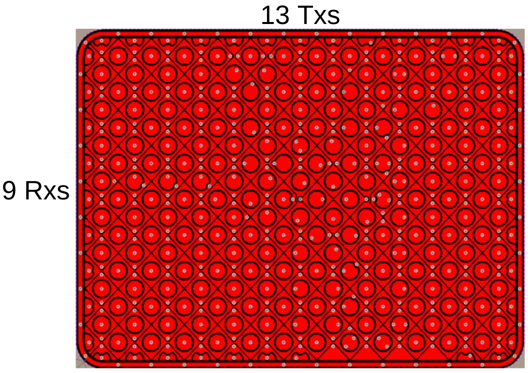
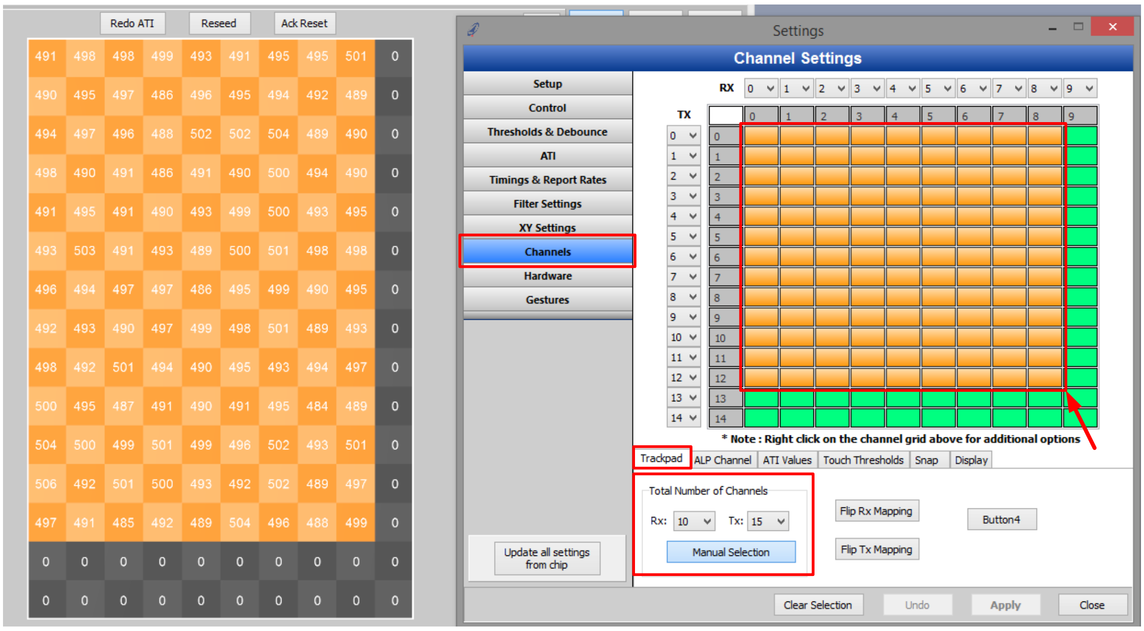


Figure 5.2 Row and column hardware

To set up the *TotalRx* and *TotalTx* parameters, go to the Channels sub-menu and click on the *Trackpad* tab. Here the dropdown menus for Rx and Tx can be set to 9 and 13 respectively, or the Manual Selection button can be pressed, and then the selection can be made graphically on the channel grid as shown in the picture below. Simply move your cursor to highlight the area implemented (indicated by the arrow for the TPS65 hardware), and click to select the implemented channels. As seen on the left in Figure 5.3, it is often easy to notice the channels implemented, since those not available will normally time-out, and have a count value of zero displayed on the main window. When Rx and Tx is correctly set, press Apply to send the settings to the IQS5xx. For the remainder of this document, it is assumed that Apply is pressed after any parameter is changed.



491	498	498	499	493	491	495	495	501	0
490	495	497	486	496	495	494	492	489	0
494	497	496	488	502	502	504	489	490	0
498	490	491	486	491	490	500	494	490	0
491	495	491	490	493	499	500	493	495	0
493	503	491	493	489	500	501	498	498	0
496	494	497	497	486	495	499	490	495	0
492	493	490	497	499	498	501	489	493	0
498	492	501	494	490	495	493	494	497	0
500	495	487	491	490	491	495	484	489	0
504	500	499	501	499	496	502	493	501	0
506	492	501	500	493	492	502	489	497	0
497	491	485	492	489	504	496	488	499	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

* Note : Right click on the channel grid above for additional options

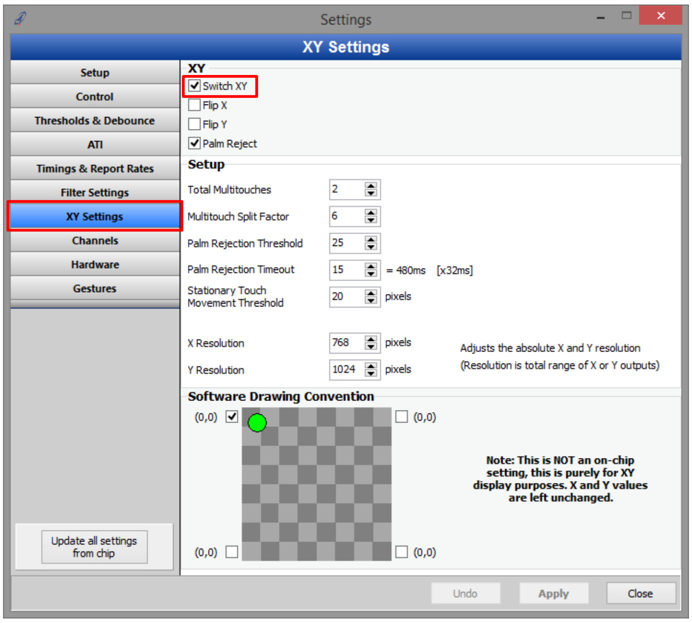
Total Number of Channels

Rx: 10 Tx: 15

Figure 5.3 Total Rx and Tx selection

5.3 X and Y axis

By default, the Rxs are columns (thus in the X direction), and Txs are rows (thus in the Y direction). If this is different, such as for the TPS65, then the axes must be switched as illustrated below.



XY

☑ Switch XY
□ Flip X
□ Flip Y
☑ Palm Reject

Setup

Total Multitouches	2	
Multitouch Split Factor	6	
Palm Rejection Threshold	25	
Palm Rejection Timeout	15	= 480ms [x32ms]
Stationary Touch Movement Threshold	20	pixels
X Resolution	768	pixels
Y Resolution	1024	pixels

Adjusts the absolute X and Y resolution (Resolution is total range of X or Y outputs)

Software Drawing Convention

(0,0) ☑ □ (0,0)
(0,0) □ □ (0,0)

Note: This is NOT an on-chip setting, this is purely for XY display purposes. X and Y values are left unchanged.

Figure 5.4 Switch XY

Note: the channel display on the main window will switch together with this configuration; but the channel grid on the Channels sub-menu will remain with the default layout.

5.4 Rx/Tx mapping

To make routing easier, the sequence of Rx and Tx is not important. If they have been routed out of sequence, this must simply be configured. The Rx and Tx numbers on the TPS65 layout are shown in the picture below (Txs being columns, and Rxs rows).

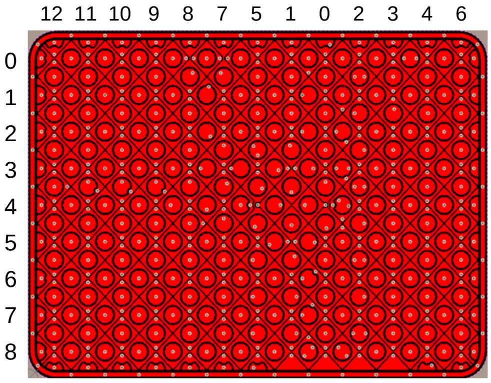
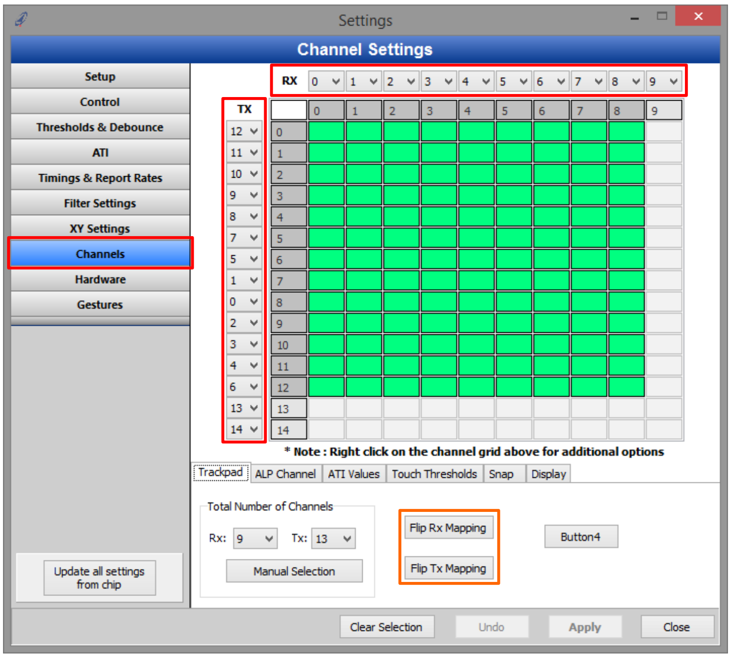


Figure 5.5 Rx/Tx hardware design

The mapping is now configured in the Channels sub-menu by modifying the dropdown selections around the main channel grid. Again remember that the Rxs are still shown above, and the Txs on the left edge. The mapping for the TPS65 hardware is configured as shown in the figure below.



RX: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

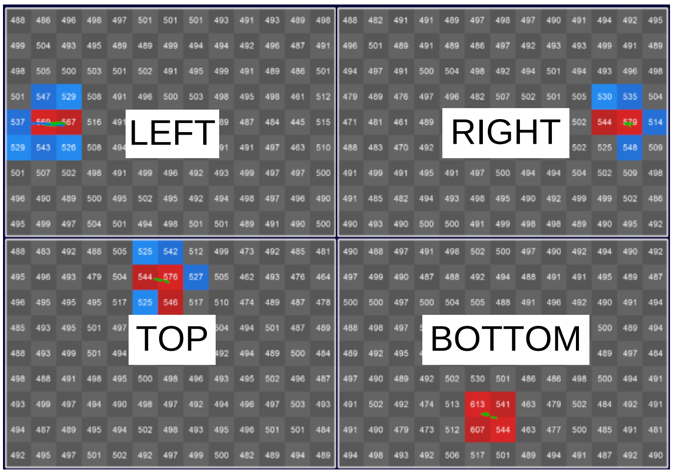
TX: 12, 11, 10, 9, 8, 7, 5, 1, 0, 2, 3, 4, 6, 13, 14

* Note : Right click on the channel grid above for additional options

Rx: 9 Tx: 13

Figure 5.6 Rx/Tx mapping setup

Confirm if the Rx/Tx mapping aligns with the channel display on the main window by touching left, right, top and bottom, and confirming whether the channels mirror the hardware locations (check only prox/touch location, for now ignore the XY position output). If these do not match the finger location on the hardware, then you can reverse the order of the Rx and Tx mapping to correct this. This can be quickly done by pressing the Flip Rx Mapping and/or Flip Tx Mapping buttons as shown in the orange square in the previous figure. This is mostly a GUI display setup, but it is beneficial that the GUI display and actual hardware location are aligned.



488	486	496	498	497	501	501	501	493	491	493	489	498
499	504	493	495	489	489	499	494	494	492	496	487	491
498	505	500	503	501	502	491	495	499	491	489	486	501
501	547	529	508	491	496	500	503	498	495	498	461	512
537	569	567	516	491				89	487	484	445	515
529	543	526	508	494				91	491	497	463	510
501	507	502	498	491	499	496	492	493	499	497	497	500
496	490	489	500	495	502	495	492	494	498	497	496	490
495	499	497	504	501	494	498	501	501	489	491	490	500

488	482	491	491	489	497	498	497	490	491	494	492	495
496	501	489	491	489	486	497	492	493	493	499	491	489
494	497	491	500	504	498	492	494	501	494	493	496	498
479	489	476	497	496	482	507	502	501	505	530	535	504
471	481	461	489						502	544	579	514
488	483	470	492						502	525	548	509
491	499	491	495	491	497	500	494	494	504	502	509	498
491	485	482	494	493	498	495	490	492	499	499	502	486
490	493	490	500	500	491	499	498	498	489	490	495	492

488	483	492	488	505	525	542	512	499	473	492	485	481
495	496	493	479	504	544	576	527	505	462	493	476	464
496	495	495	495	517	525	546	517	510	474	489	487	478
485	493	495	501	497			504	494	501	487	489
488	493	499	501	494			492	494	489	500	484
498	488	491	498	495	500	498	496	493	495	502	496	487
493	499	497	494	490	498	497	492	494	496	497	503	493
494	487	489	495	494	502	498	493	495	496	501	501	484
492	495	497	501	502	492	497	499	500	482	489	494	489

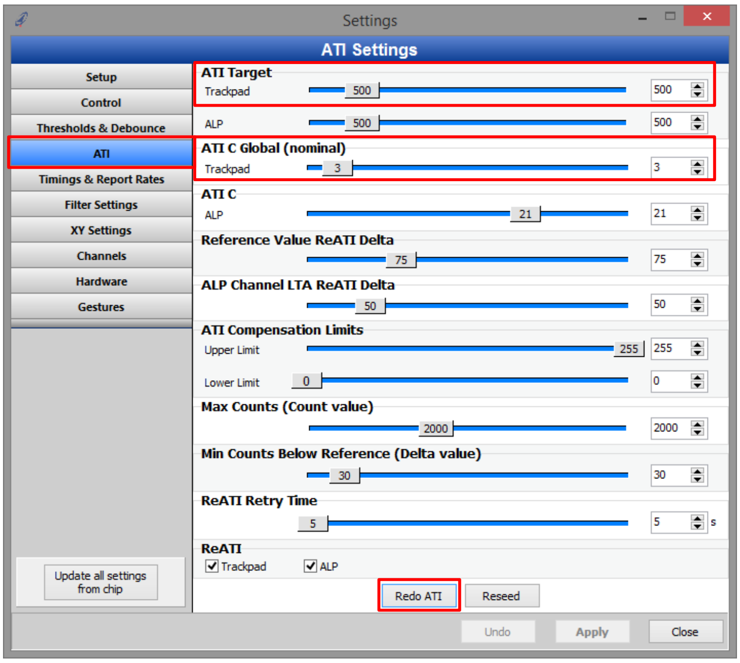
490	488	497	491	498	502	500	497	490	492	494	490	492
497	499	490	487	488	492	494	488	491	491	495	489	487
500	500	497	500	504	505	488	491	496	492	490	491	494
488	498	497	5							500	489	494
489	492	495	4							489	497	484
497	490	489	492	502	530	501	486	486	498	500	494	491
491	502	492	474	513	613	541	463	479	502	484	492	491
491	490	479	473	512	607	544	463	477	500	485	491	481
494	498	493	492	506	517	501	489	494	491	487	492	490

Figure 5.7 Channel alignment

5.5 ATI Setup

The ATI parameters are a very important step in the configuration of the IQS5xx device. The channels are configured to give acceptable sensitivity and performance. We will keep the setup basic here, but refer to Azoteq literature for further details regarding ATI technology.

Firstly adjust the *ATI C* and *ATI Target* on the ATI sub-menu to give acceptable sensitivity and performance.



ATI Target
Trackpad 500
ALP 500

ATI C Global (nominal)
Trackpad 3

ATI C
ALP 21

Reference Value ReATI Delta 75

ALP Channel LTA ReATI Delta 50

ATI Compensation Limits
Upper Limit 255
Lower Limit 0

Max Counts (Count value) 2000

Min Counts Below Reference (Delta value) 30

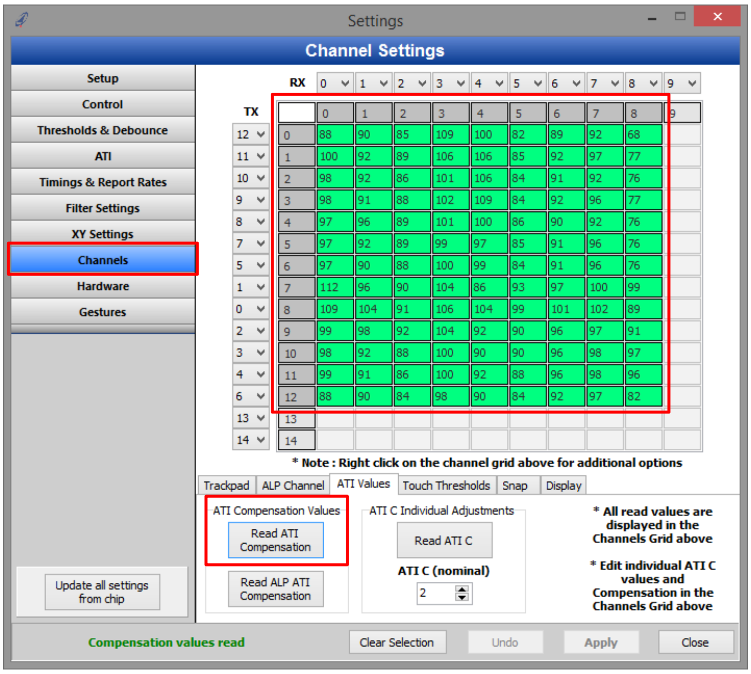
ReATI Retry Time 5 s

ReATI
☑ Trackpad ☑ ALP

Figure 5.8 ATI Setup

For the TPS65 hardware the default setup was not sensitive enough. Increasing the *ATI Target* to 700 provided better, but not good enough touch deltas, and the ATI Compensation values were also on the low side. Increasing the *ATI Target* would lift the ATI Compensation values, and increase sensitivity. The *ATI C* was on 3, so by reducing this value and keeping the *ATI Target* at 700, charging time is not increased unnecessarily, while still increasing sensitivity and ATI Compensation in the process.

ATI C = 2 and *ATI Target* = 700 gave acceptable deltas to use for an initial device setup. The ATI Compensation can be read from the device and viewed in the channel grid as illustrated below.



TX	RX	0	1	2	3	4	5	6	7	8	9
		0	1	2	3	4	5	6	7	8	9
12	0	88	90	85	109	100	82	89	92	68	
11	1	100	92	89	106	106	85	92	97	77	
10	2	98	92	86	101	106	84	91	92	76	
9	3	98	91	88	102	109	84	92	96	77	
8	4	97	96	89	101	100	86	90	92	76	
7	5	97	92	89	99	97	85	91	96	76	
5	6	97	90	88	100	99	84	91	96	76	
1	7	112	96	90	104	86	93	97	100	99	
0	8	109	104	91	106	104	99	101	102	89	
2	9	99	98	92	104	92	90	96	97	91	
3	10	98	92	88	100	90	90	96	98	97	
4	11	99	91	86	100	92	88	96	98	96	
6	12	88	90	84	98	90	84	92	97	82	
13	13										
14	14										

* Note : Right click on the channel grid above for additional options

ATI Compensation Values

ATI C Individual Adjustments

ATI C (nominal) 2

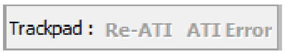
* All read values are displayed in the Channels Grid above

* Edit individual ATI C values and Compensation in the Channels Grid above

Compensation values read

Figure 5.9 ATI Compensation read

An ATI error flag on the bottom of the main window will show when there is an ATI error. This display also shows when the IQS5xx is performing a Re-ATI.



Trackpad : Re-ATI ATI Error

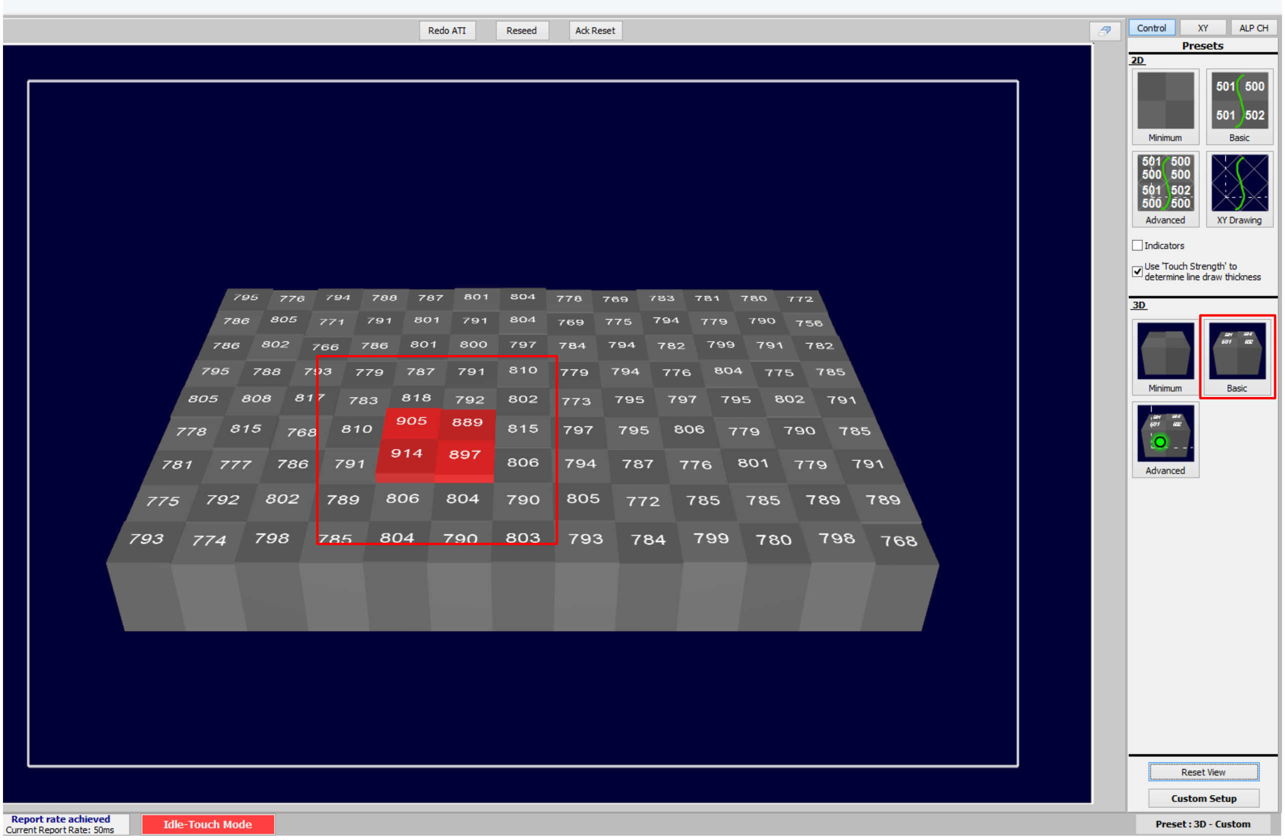
Figure 5.10 ATI error status

5.6 Thresholds

The ATI settings directly affect the channel sensitivity, so after these are modified, the thresholds usually need adjusting.

5.6.1 Touch

First configure the touch thresholds on the Thresholds & Debounce sub-menu. A suggested method is to change the main window display preset to *3D – Basic*. Now with a small finger, press lightly between 4 channels, thus trying to make the bars, representing the count values (and thus deltas) of the 4 channels, a similar height by being positioned evenly between 4 channels, as shown in the picture.



795	776	794	788	787	801	804	778	769	783	781	780	772
786	805	771	791	801	791	804	769	775	794	779	790	756
786	802	766	786	801	800	797	784	794	782	799	791	782
795	788	793	779	787	791	810	779	794	776	804	775	785
805	808	817	783	818	792	802	773	795	797	795	802	791
778	815	768	810	905	889	815	797	795	806	779	790	785
781	777	786	791	914	897	806	794	787	776	801	779	791
775	792	802	789	806	804	790	805	772	785	785	789	789
793	774	798	785	804	790	803	793	784	799	780	798	768

☐ Indicators

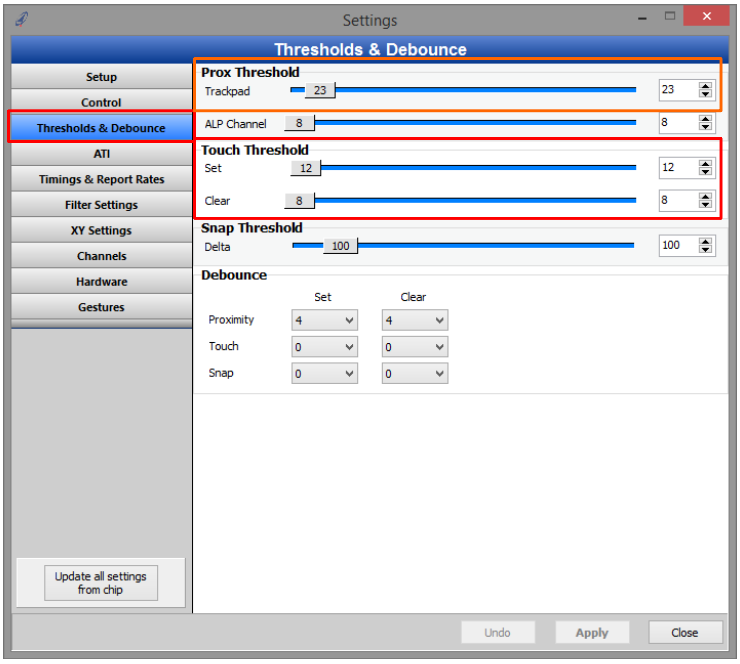
☑ Use 'Touch Strength' to determine line draw thickness

Report rate achieved
Current Report Rate: 50ms

Preset : 3D - Custom

Figure 5.11 Small touch

This therefore places the finger furthest away from the four channel centres (their most sensitive areas), giving a good indication of a weak touch that should still be detected. Set both the *touch set* and *clear* threshold to the same value, so that a touch (red display squares) just starts to become detected on these 4 squares. Thresholds are set as illustrated below.



Prox Threshold

Trackpad 23

ALP Channel 8

Touch Threshold

Set 12

Clear 8

Snap Threshold

Delta 100

Debounce

	Set	Clear
Proximity	4	4
Touch	0	0
Snap	0	0

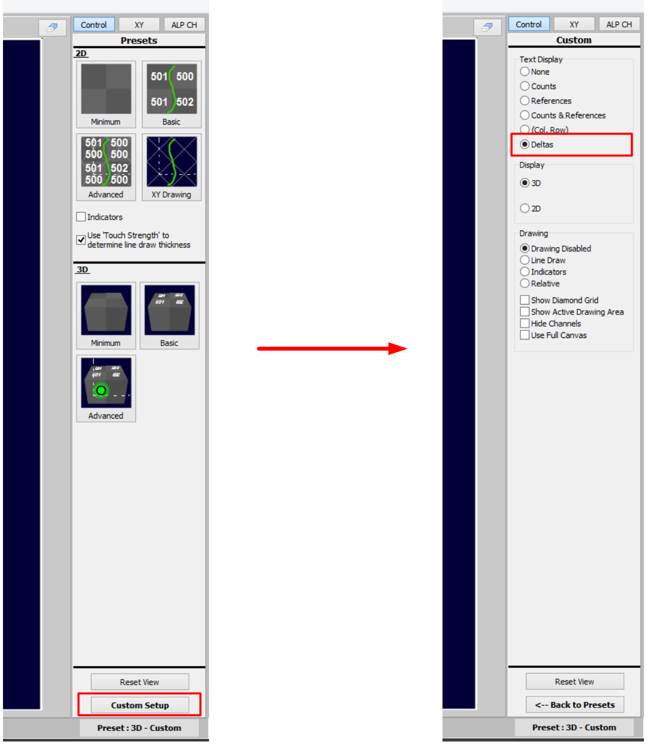
Figure 5.12 Touch thresholds

Now add a hysteresis to the touch thresholds by decreasing the *touch clear* value so that jitter is not seen on touch outputs, because a touch release is now at a more sensitive threshold value compared to the threshold where a touch becomes set. The four channels in the above test should also now all detect constant touch outputs.

5.6.2 Prox

Next, the trackpad prox threshold should be set (shown in orange square of previous picture) higher than the expected noise seen on the count values. The TPS65 proximity threshold can be set to about 30 for the current noise environment, keeping in mind that the default debounce is set to 4.

The deltas on the channels can be viewed by enabling *Deltas* on the custom display parameters, as shown below.



☐ Indicators
☑ Use 'Touch Strength' to determine line draw thickness

Preset : 3D - Custom

Text Display
○ None
○ Counts
○ References
○ Counts & References
○ (Col, Row)
● Deltas

Display
● 3D
○ 2D

Drawing
● Drawing Disabled
○ Line Draw
○ Indicators
○ Relative
☐ Show Diamond Grid
☐ Show Active Drawing Area
☐ Hide Channels
☐ Use Full Canvas

Preset : 3D - Custom

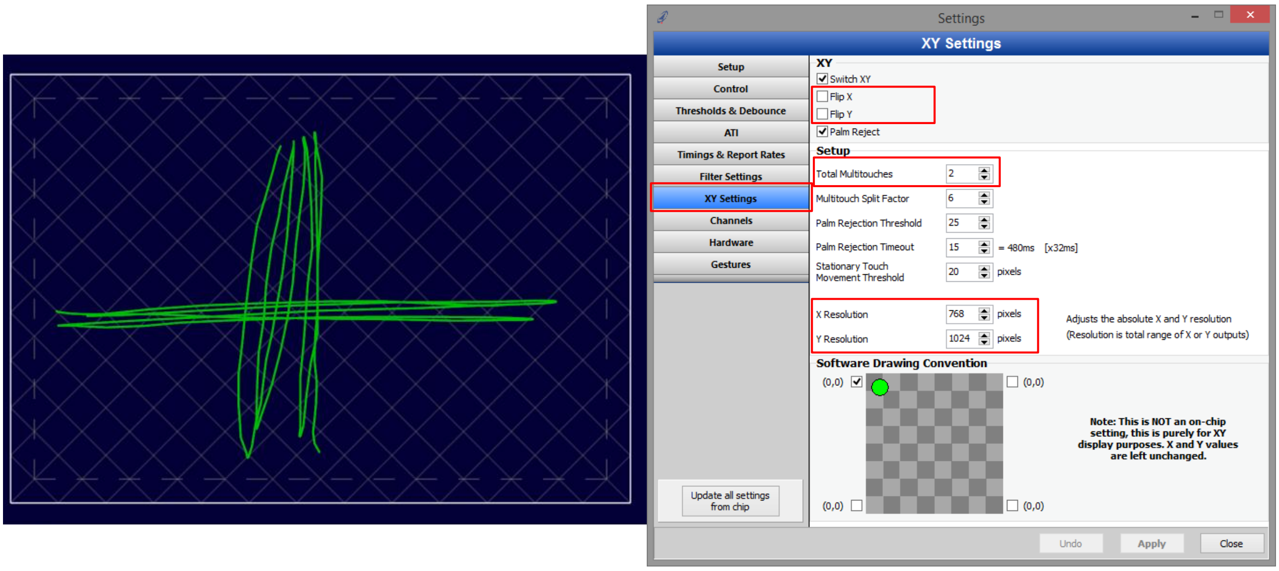
Figure 5.13 Delta view selection

5.7 XY Output

Now with basic channel sensitivity and thresholds configured, the XY outputs can be evaluated and adjusted on the XY Settings sub-menu.

5.7.1 XY polarity

Firstly, make sure the X output polarity is correct, by drawing left to right. If the output from the device is not as desired, then select *Flip X* to change the on-chip output polarity. Repeat this for the Y output. X and Y flipping was not required on the TPS65.



XY
☑ Switch XY
☐ Flip X
☐ Flip Y
☑ Palm Reject

Setup
Total Multitouches 2
Multitouch Split Factor 6
Palm Rejection Threshold 25
Palm Rejection Timeout 15 = 480ms [x32ms]
Stationary Touch Movement Threshold 20 pixels

X Resolution 768 pixels
Y Resolution 1024 pixels
Adjusts the absolute X and Y resolution
(Resolution is total range of X or Y outputs)

Software Drawing Convention
(0,0) ☑ ☐ (0,0)
(0,0) ☐ ☐ (0,0)

Note: This is NOT an on-chip setting, this is purely for XY display purposes. X and Y values are left unchanged.

Figure 5.14 XY output configuration

5.7.2 Total multi-touches

Also set the *total multi-touches* that are required for the design. Remember if more than the configured value are sensed, then all outputs are cleared until the total is less than or equal to that configured. So if post-processing will reject unwanted points, then set this value higher so that XY outputs are still provided to the master device for post-processing.

5.7.3 Output resolution

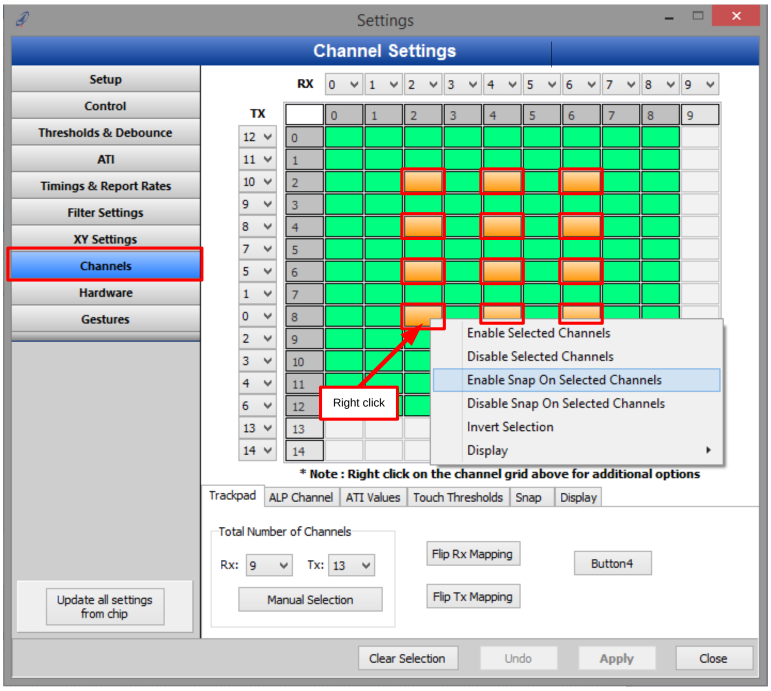
The *XY resolution* parameters are also shown in the previous picture. Here the total resolution across the screen can be set as required.

5.8 Snap configuration

For designs that have snap channels, these need to be defined (enabled). The TPS65 does not have snap outputs, so this section does not apply.

To enable snap channels, go to the Channels sub-menu, and then highlight only the specific channels that must give snap outputs. Highlight multiple channels by pressing and holding *Ctrl* and then clicking on the channels in the channel grid. With the snap channels all selected, right click and select *Enable snap on selected channels*.

Don't enable snap on channels that are not implemented as snap channels! This is because decisions regarding channel behaviour are made differently depending on whether a channel has snap functionality or not.



* Note : Right click on the channel grid above for additional options

Total Number of Channels
Rx: 9 Tx: 13

Figure 5.15 Snap channel enable

5.9 Basic setup summary

At this point the device is operational. The hardware (layout and sensor design) has been configured on the device and the ATI parameters have been adjusted to allow for adequate sensing of user interaction. Thresholds have been set so that inputs are reliably detected, and accurate XY outputs are obtained.

The power modes of the device have not been changed, and at this point the power modes will cause the device to automatically make a transition from the *Idle* state to the *LP1* state, and then further to the *LP2* state. The report rates of the different states are also standard values for this configuration, and provide sufficiently low power consumption.

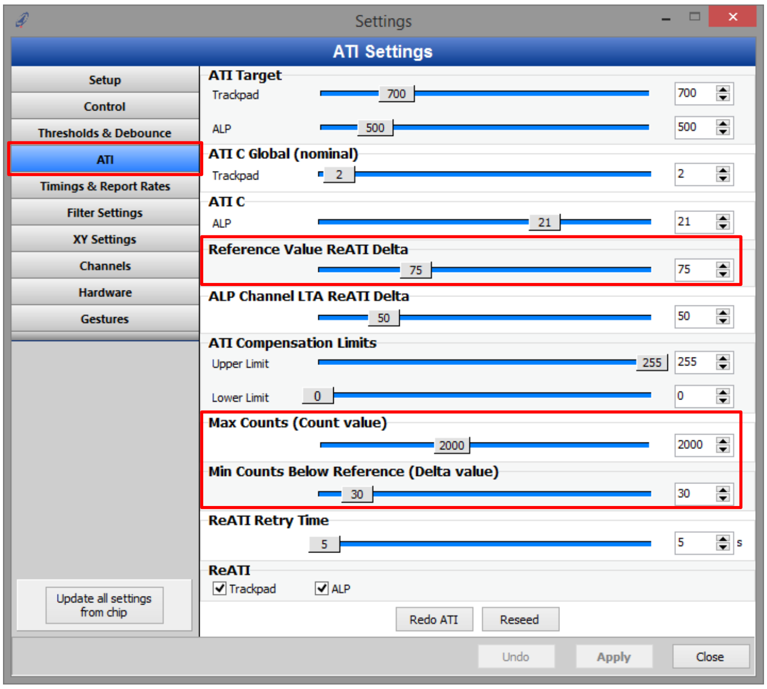
The different power modes on the B000 are implemented by controlling the rate with which the sensors are scanned. The low-power modes are simply modes where scan rates with lower duty cycles are used.

Currently the complete trackpad is sensed in *LP1/LP1,* which is the easier option and is recommended from an ease of design and performance perspective.

At this point gesture outputs should also be visible, unless if the hardware is very different from standard designs. In that case the gesture parameters would need to be optimised.

6 Advanced setup

6.1 ATI and Re-ATI conditions



ATI Target
Trackpad 700
ALP 500

ATI C Global (nominal)
Trackpad 2

ATI C
ALP 21

Reference Value ReATI Delta 75

ALP Channel LTA ReATI Delta 50

ATI Compensation Limits
Upper Limit 255
Lower Limit 0

Max Counts (Count value) 2000

Min Counts Below Reference (Delta value) 30

ReATI Retry Time 5 s

ReATI
☑ Trackpad ☑ ALP

Figure 6.1 ATI and Re-ATI advanced setup

6.1.1 Re-ATI deltas

The delta that the reference values are allowed to drift away from the ATI Target, before a Re-ATI is automatically performed, can be adjusted here. This value should be selected so that a reasonable deviation needs to be seen on the counts before a Re-ATI is triggered.

6.1.2 Max count

The maximum count parameter is used to sense for incorrect sensor behaviour. If a count value larger than this value is sensed for 14 consecutive measurements, then a Re-ATI is triggered. This value should be configured as a count value that is unreachable by normal user interaction with the sensor (plus noise).

For example, if an ATI is executed during a snap button press, then the count value is very low due to the snap press. The ATI algorithm will configure a high ATI Compensation value for that channel, to attempt to increase the count values to the ATI Target. If the snap button is then later released, then the count value will increase drastically due to the large ATI Compensation set up for that channel. This will normally be a much larger increase than what can be achieved by making a normal trackpad touch on a correctly configured channel, thereby differentiating this problem scenario.

6.1.3 Min count

The minimum count parameter also monitors for incorrect sensor behaviour. In this case, since a projected-capacitive sensor increases under user interaction, a decrease in count values is against expectation. This parameter is a delta value below the reference.

A channel that is configured to have snap functionality can sense a decrease in counts during the snap action. For this reason, snap channels are specifically differentiated from non-snap channels by defining them as such during the configuration. Therefore only non-snap channels are monitored for unexpected decreases in count value. If 14 consecutive negative deltas are sensed below the min value delta, a Re-ATI is triggered.

Some sensors exhibit a sensor saturation effect under certain conditions. This saturation causes a reverse effect on the count values, and care must be taken to select a threshold below this decrease. Also the design must be optimised to reduce this effect as far as possible.

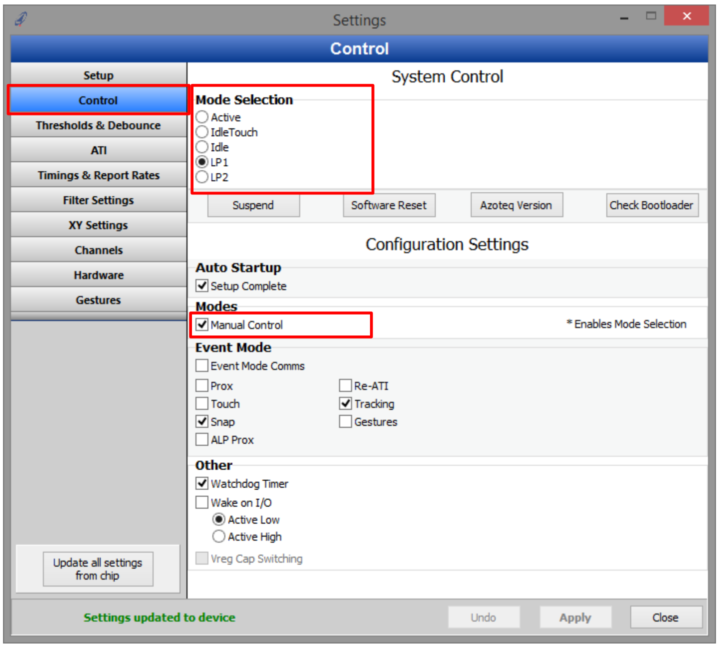
The main scenario that is addressed by this parameter is when an ATI is configured while a user is touching / interacting with the trackpad. Because the user is touching the trackpad, the count values are higher than normal. Therefore to reach the ATI Target value, less ATI Compensation will be configured on the affected channels. If the touch is later removed, the count values will decrease, and their sensitivity will also be greatly reduced compared to other correctly configured channels. To recover from this, the decline in count values on non-snap channels will be detected after the finger removal, and a Re-ATI will trigger and correct the previous incorrect configuration.

6.2 Alternate LP channel (ALP) setup

Using the trackpad for *LP1/LP2* is the easier option if power consumption is not critical. However to obtain roughly 10 times less current (comparing a full 15x10 trackpad consumption to an individual ALP channel consumption) an alternate single channel setup can be configured as the low-power channel. This channel then needs to detect user interaction to wake the device from *LP1/LP2* and to make a transition to the trackpad sensing state (*Idle* mode). Due to this, it is normally set up using alternating sensors on the trackpad, or a similar configuration providing enough coverage area and wake-up capability on the trackpad. The ALP channel is sensed in a single time-slot, so Txs are not scanned as done for the trackpad sensing.

6.2.1 Mode configuration for ALP setup

During the ALP channel configuration it is best to manually control the system mode by forcing it into LP1. To do this, go to the Control sub-menu, select *Manual Control*, and then change the mode to *LP1*. The status bar at the bottom edge of the main window should now indicate that the device is in *LP1* mode.



System Control

Mode Selection
○ Active
○ IdleTouch
○ Idle
● LP1
○ LP2

Configuration Settings

Auto Startup
☑ Setup Complete

Modes
☑ Manual Control   * Enables Mode Selection

Event Mode
□ Event Mode Comms
□ Prox   □ Re-ATI
□ Touch   ☑ Tracking
☑ Snap   □ Gestures
□ ALP Prox

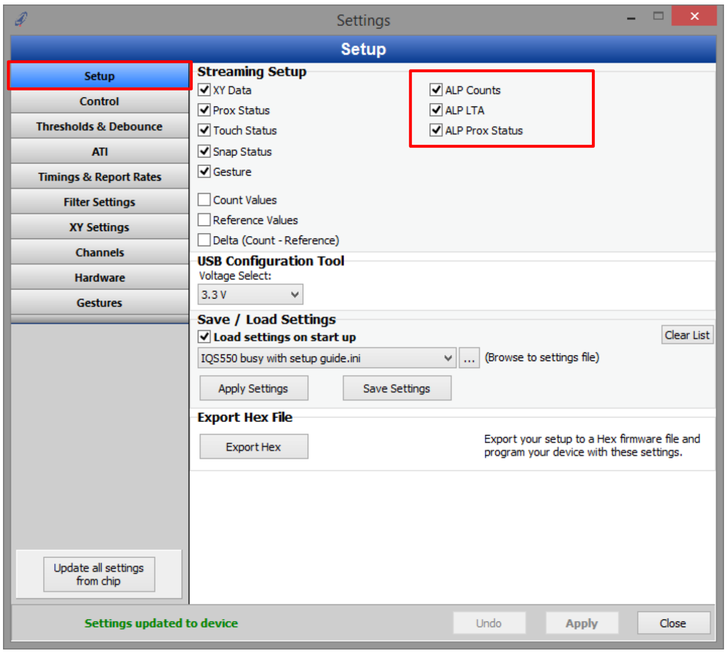
Other
☑ Watchdog Timer
□ Wake on I/O
● Active Low
○ Active High
□ Vreg Cap Switching

Settings updated to device

Figure 6.2 Forcing LP1 mode for ALP configuration

6.2.2 ALP streaming data

Now enable the data streaming of the ALP channel, by going to the Setup sub-menu, and enabling the ALP data as shown in the picture below.



Streaming Setup
☑ XY Data   ☑ ALP Counts
☑ Prox Status   ☑ ALP LTA
☑ Touch Status   ☑ ALP Prox Status
☑ Snap Status
☑ Gesture
□ Count Values
□ Reference Values
□ Delta (Count - Reference)

USB Configuration Tool
Voltage Select:
3.3 V

Save / Load Settings
☑ Load settings on start up
IQS550 busy with setup guide.ini   (Browse to settings file)

Export Hex File
Export your setup to a Hex firmware file and program your device with these settings.

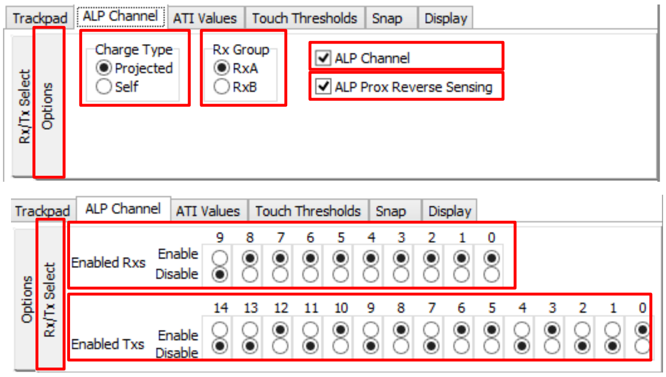
Settings updated to device

Figure 6.3 Enable ALP stream data

To view the ALP streaming data, change the tab to the right of the main window by clicking the ALP CH button. The ALP channel is not yet enabled, so nothing will show at this stage.

6.2.3 Enable ALP

The ALP channel setup is done on the Channels sub-menu, under the *ALP Channel* tab. Note that this tab also has two further tab selections on the left, as illustrated in the picture below. The top version is when the left tab is set to *Options*, and the bottom one is when set to *Rx/Tx Select*.



Charge Type
● Projected
○ Self

Rx Group
● RxA
○ RxB

☑ ALP Channel

☑ ALP Prox Reverse Sensing

Enabled Rxs	9	8	7	6	5	4	3	2	1	0
Enable	○	●	●	●	●	●	●	●	●	●
Disable	●	○	○	○	○	○	○	○	○	○

Enabled Txs	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Enable	○	○	●	○	●	○	●	○	●	●	○	●	○	○	●
Disable	●	●	○	●	○	●	○	●	○	○	●	○	●	●	○

Figure 6.4 ALP channel setup tabs and options

Change the *LP1/LP2* charging scheme from the complete trackpad to a single ALP channel by enabling the ALP channel under the *Options* tab on the left.

6.2.4 Charging type

Here *projected*- or *self*-capacitive charging can be configured. Normally the trackpad sensors are used, and therefore projected-capacitance is used most often. If an additional sensor is designed using an unused Rx it could be possible to configure this as a self-capacitive sensor.

Another option on a product that will be earthed (otherwise this is not effective) is to run an unused (or B group) Rx around the trackpad perimeter, and to then enable this together with all of the trackpad Txs, giving good sensitivity for a short-range proximity wake-up on the ALP channel.

6.2.5 ALP sensor configuration

Set the Rxs and Txs to be used for the ALP channel by enabling them individually. Often the ALP channel is difficult to configure, so switching between the sensor configuration and the ATI settings to monitor performance, sensitivity, and ATI Compensation values is done, until a suitable configuration is obtained.

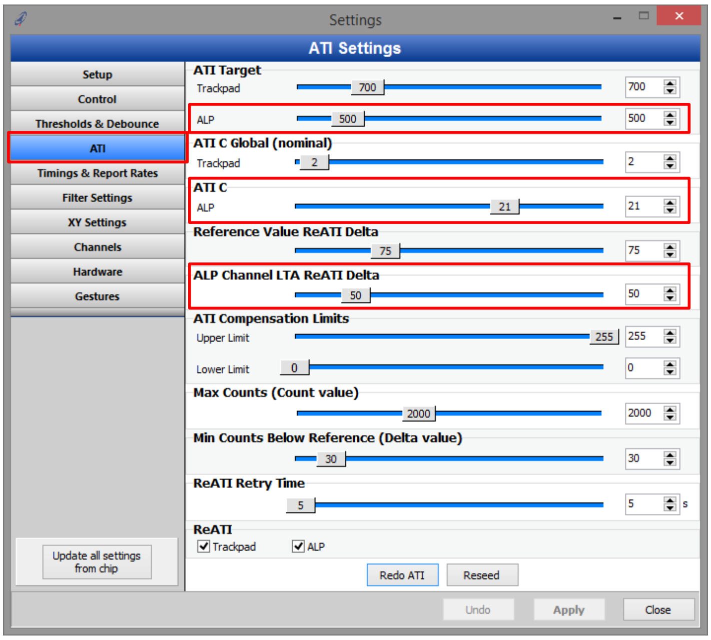
For the TPS65 module, the settings shown in Figure 6.4 were implemented. Using alternating Txs and all the Rxs on the trackpad is usually a reliable option. Thus you can see the applicable channels for the 13x9 trackpad are enabled for the ALP of the TPS65.

Note1: Remember that the Txs are not sequential on the TPS65, so take care to select every second Tx as defined by the trackpad layout.

Note2: At this stage the ALP channel is set to a very slow report rate (LP1 = 200ms and LP2 = 400ms). This was for the case where the trackpad was previously sensed during the LP-modes. It is recommended for evaluation to reduce the report rate (For example I used LP1 = 75, LP2 = 200) to get better performance. Modifying the report rate is explained further on in this document.

6.2.6 ALP ATI setup

The ATI of the ALP channel is also set up on the ATI sub-menu. Here the *ATI C* and *ATI Target* can be selected to configure the ALP channel.



Settings

ATI Settings

ATI Target
Trackpad 700
ALP 500

ATI C Global (nominal)
Trackpad 2

ATI C
ALP 21

Reference Value ReATI Delta 75

ALP Channel LTA ReATI Delta 50

ATI Compensation Limits
Upper Limit 255
Lower Limit 0

Max Counts (Count value) 2000

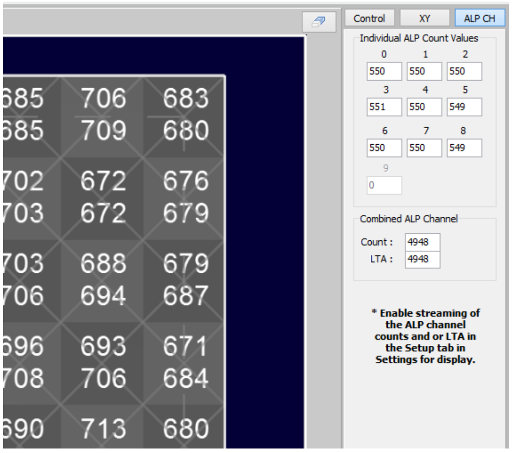
Min Counts Below Reference (Delta value) 30

ReATI Retry Time 5 s

ReATI
☑ Trackpad ☑ ALP

Figure 6.5 ALP ATI settings

This *ATI C* value will be used for each Rx which is enabled on the ALP channel. Also, the *ATI Target* is the individual Rx channel target value, meaning that each Rx channel will aim to reach this target, and the integrated ALP ‘channel’ will thus be a sum of all of these individual count values. This is clear by looking at the data received from the device for the ALP channel on the right of the main window (for an ATI Target of 550):



```
685  706  683
685  709  680

702  672  676
703  672  679

703  688  679
706  694  687

696  693  671
708  706  684

690  713  680
```

Individual ALP Count Values

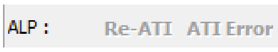
0	1	2
550	550	550
3	4	5
551	550	549
6	7	8
550	550	549
9		
0		

Combined ALP Channel
Count : 4948
LTA : 4948

* Enable streaming of the ALP channel counts and or LTA in the Setup tab in Settings for display.

Figure 6.6 ALP channel data

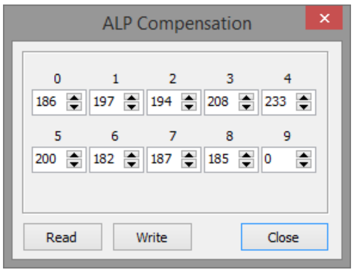
Using the default ATI C (21) and ATI Target (500) values, there is no ATI Error flag shown in the status area (bottom of main window) for the ALP channel, as shown in the picture below.



ALP : Re-ATI ATI Error

Figure 6.7 ATI error status

This means that the ATI Compensation is within the limits (which are currently set to 0 and 255, as visible in Figure 6.5). The ATI Compensation can be viewed in a similar fashion as the trackpad channel by going to the Channels sub-menu, selecting the *ATI Values* tab, and pressing the Read ALP ATI Compensation button. This will bring up a small window showing the ATI Compensation for each active Rx in the ALP configuration.



ALP Compensation

0	1	2	3	4
186	197	194	208	233

5	6	7	8	9
200	182	187	185	0

Figure 6.8 ALP ATI Compensation

These values are on the upper side of the ATI Compensation range, so it is best to reduce them so that product and temperature variation can be accounted for. For the TPS65 an ATI C of 22 and an ATI Target of 550 were selected, giving good performance and ATI Compensation in the centre of the range.

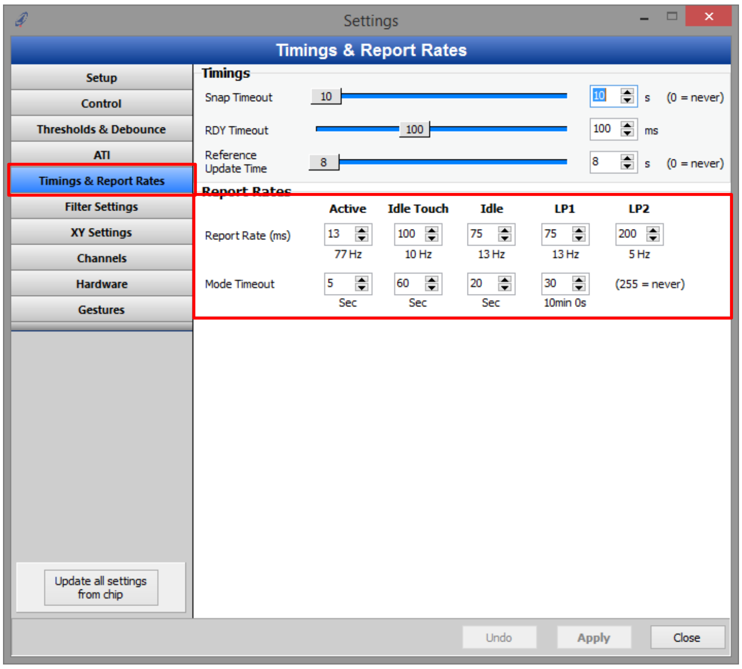
6.2.7 ALP thresholds

Now the proximity threshold of the ALP channel must be configured so that reliable wake-up is achieved, without unnecessary wake-up from noise. This is also set under the Thresholds & Debounce sub-menu. For the TPS65 a value of 6 was selected, providing reliable wake-up when using the trackpad.

6.3 Mode configuration

Remember to disable *Manual Control* under the Control sub-menu since the ALP setup is complete.

The mode settings are configured under the Timings & Report Rates sub-menu, as highlighted in the picture below.



Settings

Timings & Report Rates

Timings

Snap Timeout 10 — 10 s (0 = never)

RDY Timeout 100 — 100 ms

Reference Update Time 8 — 8 s (0 = never)

Report Rates

	Active	Idle Touch	Idle	LP1	LP2
Report Rate (ms)	13 77 Hz	100 10 Hz	75 13 Hz	75 13 Hz	200 5 Hz
Mode Timeout	5 Sec	60 Sec	20 Sec	30 10min 0s	(255 = never)

Figure 6.9 Mode settings

6.3.1 Report rates

The report rate settings are normally driven by the power consumption budget of the design. A slow report rate will reduce the average consumption because the IQS5xx will have longer periods of low-power sleep added to obtain the selected report rate. The reaction speed required on the trackpad must be taken into account when selecting the *Active* mode report rate, and the wake-up capability from low-power must be taken into account when setting the *LP1* and *LP2* report rates. For the TPS65, fast response is needed from the trackpad, so a 13ms report rate is selected for *Active* mode. The *Idle* mode saves power when the finger is lifted, but must still give quick response when a gesture is performed, so 75ms is chosen. The low-power modes use the ALP channel, which has lower consumption than using the trackpad in LP1/LP2. So there is some room to increase the report rate for a faster wake-up response. LP1 = 75ms and LP2 = 200ms was selected for this example.

When a long stationary touch is detected, the system enters *Idle-Touch* mode, and its report rate is set to 100ms for the TPS65 example.

Remember that streaming large amounts of I^{2}C data in the GUI can cause the report rate to not be achieved, or increases the current consumption, so always remember to reduce the data to the minimal needed when doing such evaluations. The report rate obtained on the IQS5xx is visible on the status section at the bottom of the main window. A status bit also indicates when the rate could not be achieved. These are mainly for development purposes.

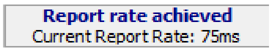

Report rate achieved
Current Report Rate: 75ms

Figure 6.10 Report rate feedback from IQS5xx

6.3.2 Mode timings

The timings responsible for transitions between the modes can be configured. The *Active Mode* timeout selects how long a stationary finger must be sensed before stepping to *Idle-Touch* mode.

The *Idle-Touch* timeout sets how long a stationary finger in *Idle-Touch* will be allowed before it is seen as a ‘stuck’ condition, and a reseed is triggered. Often this is disabled and handled by the host, then just set this value to ‘255’, meaning ‘disabled’.

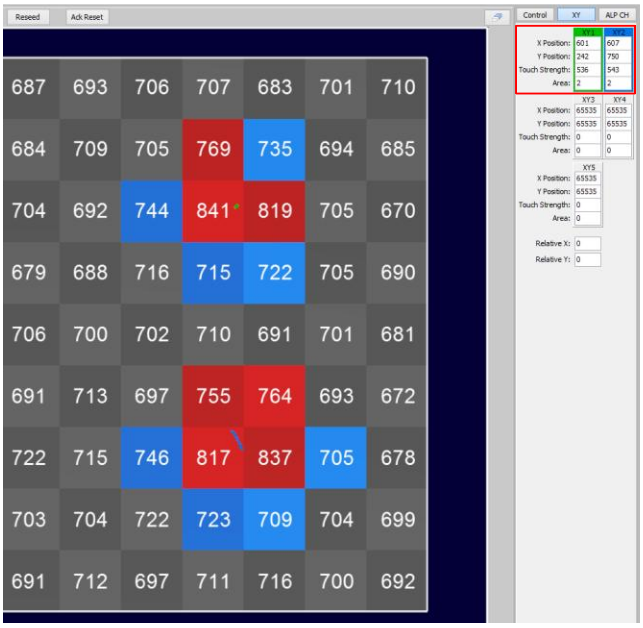
The *Idle* timeout sets how long the system stays in *Idle* mode before stepping to the next power state (*LP1*). The *LP1* timeout is the same, and determines the length of time spent in *LP1*. If *LP2* is configured as a very low power (and thus slow response) state, the *LP1* timeout is usually set quite long, so that this is only entered when the user has stopped using the device for a long time, and then extreme low-power is entered.

The default values have been kept for the TPS65 example.

6.4 Palm reject setup

The XY outputs can be rejected if a large touch (palm) is detected. The size of the palm needs to be configured, and also the delayed rejection time after the palm is no longer sensed (to prevent switching in and out of palm rejection when the size is near the threshold).

To set these parameters, it is useful to view the XY data from the device. On the main window press the XY button to the right to view the co-ordinate data received from the device, as shown in the picture below with two fingers active.



687	693	706	707	683	701	710
684	709	705	769	735	694	685
704	692	744	841	819	705	670
679	688	716	715	722	705	690
706	700	702	710	691	701	681
691	713	697	755	764	693	672
722	715	746	817	837	705	678
703	704	722	723	709	704	699
691	712	697	711	716	700	692

	XY1	XY2
X Position:	601	607
Y Position:	242	750
Touch Strength:	536	543
Area:	2	2

	XY3	XY4
X Position:	65535	65535
Y Position:	65535	65535
Touch Strength:	0	0
Area:	0	0

	XY5
X Position:	65535
Y Position:	65535
Touch Strength:	0
Area:	0

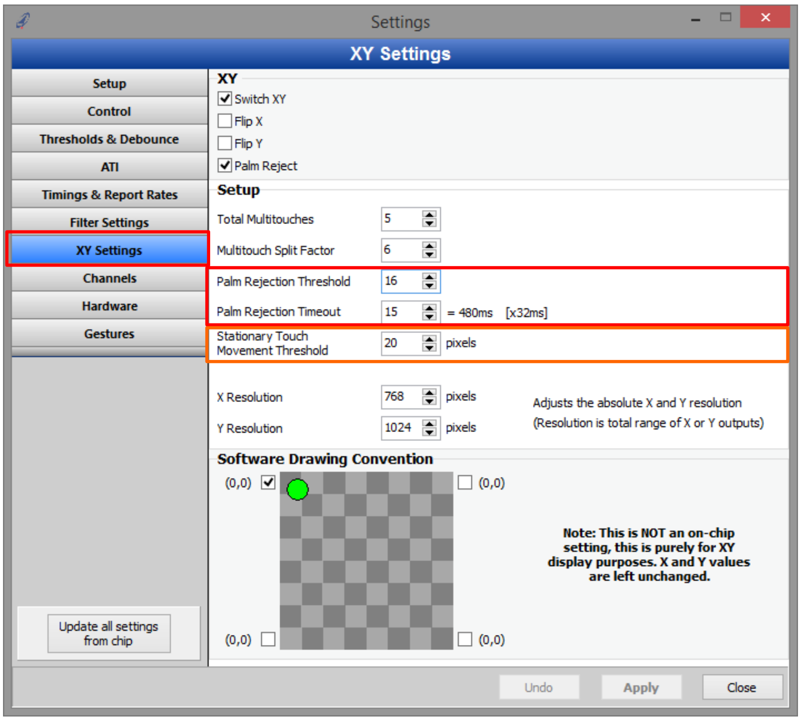
Relative X: 0
Relative Y: 0

Figure 6.11 XY data display

Note: If nothing is visible here while touching, it might be required to enable the XY data streaming in the Setup sub-menu.

Now with this information visible, make the largest acceptable touch that must still give XY output, and note the *Area* parameter for this maximum size touch.

The *Palm reject threshold* is defined as a touch 'area' that should reject the input, meaning it should be selected larger than the maximum inputs' area, as just observed in the previous step. To configure this threshold, go to the XY Settings sub-menu, and modify the threshold as shown in the picture below.



XY

☑ Switch XY
☐ Flip X
☐ Flip Y
☑ Palm Reject

Setup

Total Multitouches 5
Multitouch Split Factor 6
Palm Rejection Threshold 16
Palm Rejection Timeout 15 = 480ms [x32ms]
Stationary Touch Movement Threshold 20 pixels

X Resolution 768 pixels
Y Resolution 1024 pixels
Adjusts the absolute X and Y resolution
(Resolution is total range of X or Y outputs)

Software Drawing Convention

(0,0) ☑ ☐ (0,0)
(0,0) ☐ ☐ (0,0)

Note: This is NOT an on-chip setting, this is purely for XY display purposes. X and Y values are left unchanged.

Figure 6.12 Palm reject parameters

For the TPS65 a large flat thumb gave an area of roughly 14, so the *palm reject threshold* was chosen as 16. Now a palm reject status is shown on the main window when a palm is placed on the trackpad, and XY points are rejected.

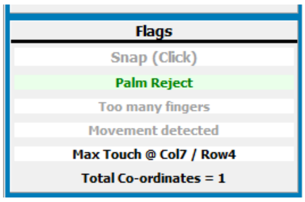

Flags
Snap (Click)
Palm Reject
Too many fingers
Movement detected
Max Touch @ Col7 / Row4
Total Co-ordinates = 1

Figure 6.13 Palm reject status indication

6.5 Stationary touch setup

For applications where the user could rest his/her finger on the trackpad for long periods of time, it is beneficial for power consumption to utilise the *Idle-Touch mode*. From the system mode state diagram in the datasheet, it is clear that the system will remain in the *Active* mode during a touch if consistent finger movement is detected. However if the finger becomes stationary for the length of time configured, then the mode will change to *Idle-Touch*. The number of pixels that the finger needs to move before it is classified as 'movement' can be configured in the XY Settings sub-menu, by changing the *Stationary touch movement threshold*, shown in the orange square in Figure 6.12.

If movement is detected on the IQS5xx it is visible in a status flag which is displayed on the main window.

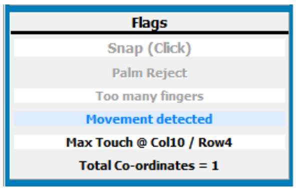
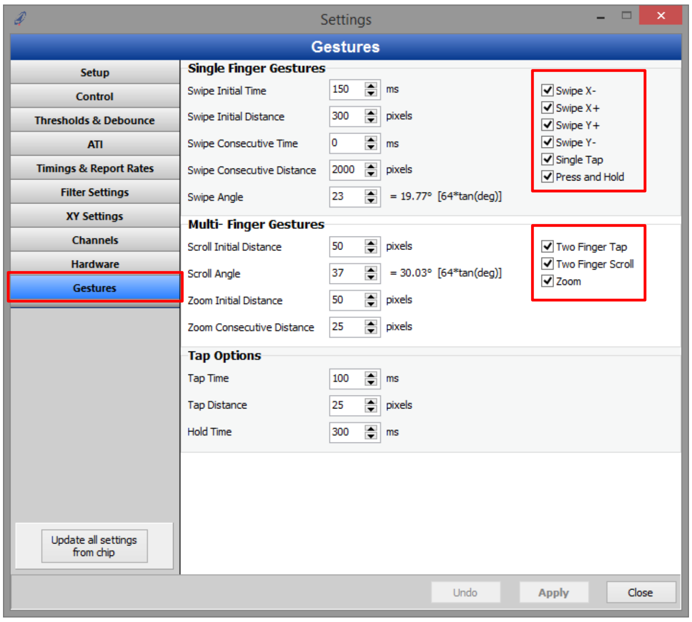

Flags
Snap (Click)
Palm Reject
Too many fingers
Movement detected
Max Touch @ Col10 / Row4
Total Co-ordinates = 1

Figure 6.14 Movement detected flag

6.6 Gesture setup



Single Finger Gestures

Swipe Initial Time	150	ms
Swipe Initial Distance	300	pixels
Swipe Consecutive Time	0	ms
Swipe Consecutive Distance	2000	pixels
Swipe Angle	23	= 19.77° [64*tan(deg)]

☑ Swipe X-
☑ Swipe X+
☑ Swipe Y+
☑ Swipe Y-
☑ Single Tap
☑ Press and Hold

Multi- Finger Gestures

Scroll Initial Distance	50	pixels
Scroll Angle	37	= 30.03° [64*tan(deg)]
Zoom Initial Distance	50	pixels
Zoom Consecutive Distance	25	pixels

☑ Two Finger Tap
☑ Two Finger Scroll
☑ Zoom

Tap Options

Tap Time	100	ms
Tap Distance	25	pixels
Hold Time	300	ms

Figure 6.15 Gesture parameters

The gestures required can be enabled, and those not implemented can be disabled. These are set on the Gestures sub-menu along with other timing, distance and angle parameters. More details on the functionality of these can be obtained in the datasheet.

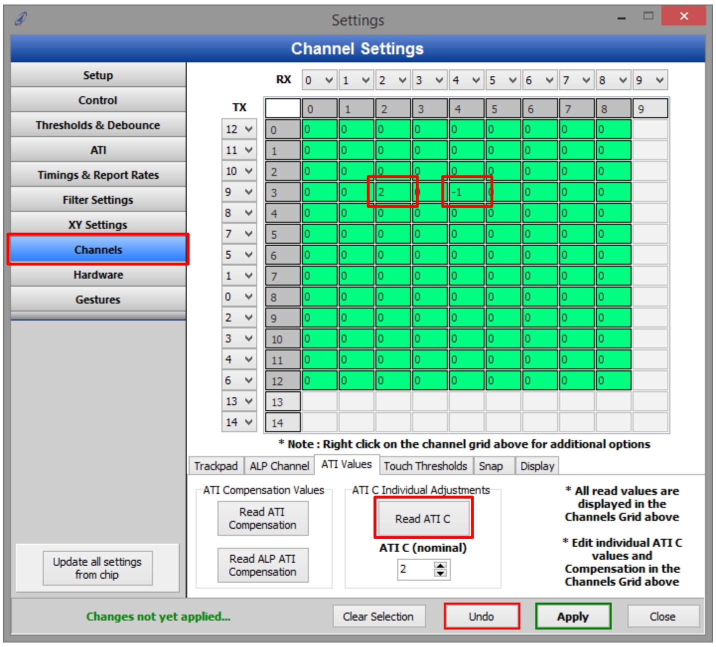
6.7 Individual channel adjustments

In some cases it could be required to individually adjust the ATI C or touch threshold parameter of a channel. Often this is forced by hardware limitations, such as cases when there is variation in the overlay material or thickness. Since the quality of the XY output depends on channels having similar performance (mainly similar deltas), sometimes individual adjustment is needed. For the TPS65 the overlay is uniform, so this section does not apply.

6.7.1 ATI C individual adjust

Since all channels have the same ATI Target, the sensitivity of a channel can be decreased by increasing the ATI C value, or the sensitivity can be increased by decreasing the ATI C value.

To perform an individual ATI C adjustment, go to the Channels sub-menu and select the *ATI Values* tab. Read the individual ATI C adjustment values by pressing Read ATI C. At this point the channel grid should be populated by 0's. This means that no channels have any adjustments made, since these are signed adjustment values which are added to the current global ATI C setting.



RX: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

TX		0	1	2	3	4	5	6	7	8	9
12	0	0	0	0	0	0	0	0	0	0	
11	1	0	0	0	0	0	0	0	0	0	
10	2	0	0	0	0	0	0	0	0	0	
9	3	0	0	2	0	-1	0	0	0	0	
8	4	0	0	0	0	0	0	0	0	0	
7	5	0	0	0	0	0	0	0	0	0	
5	6	0	0	0	0	0	0	0	0	0	
1	7	0	0	0	0	0	0	0	0	0	
0	8	0	0	0	0	0	0	0	0	0	
2	9	0	0	0	0	0	0	0	0	0	
3	10	0	0	0	0	0	0	0	0	0	
4	11	0	0	0	0	0	0	0	0	0	
6	12	0	0	0	0	0	0	0	0	0	
13	13										
14	14										

* Note : Right click on the channel grid above for additional options

ATI C (nominal): 2

* All read values are displayed in the Channels Grid above

* Edit individual ATI C values and Compensation in the Channels Grid above

Changes not yet applied...

Figure 6.16 Individual ATI C adjustment

In the picture above, two channels have individual ATI C adjustments. Their ATI C values are thus 4 and 1. This is because the global (nominal) value is 2, the first channel has an ATI C value that is equal to the global value plus 2, and the second channel has an ATI C value that is equal to the global value minus 1.

6.7.2 Touch threshold individual adjust

Individual touch set and clear threshold adjustments can be made. This is usually not ideal because a different threshold indicates a different sensitivity, which is bad for XY accuracy. However, this is sometimes still required to prevent an overly sensitive channel from false touch detections.

In the same manner as with the ATI C, click the *Touch Thresholds* tab, and then go about adding adjustments to the required channels. Note that this value adjusts the set and clear thresholds.

6.8 Event mode I²C

6.8.1 Event mode configuration

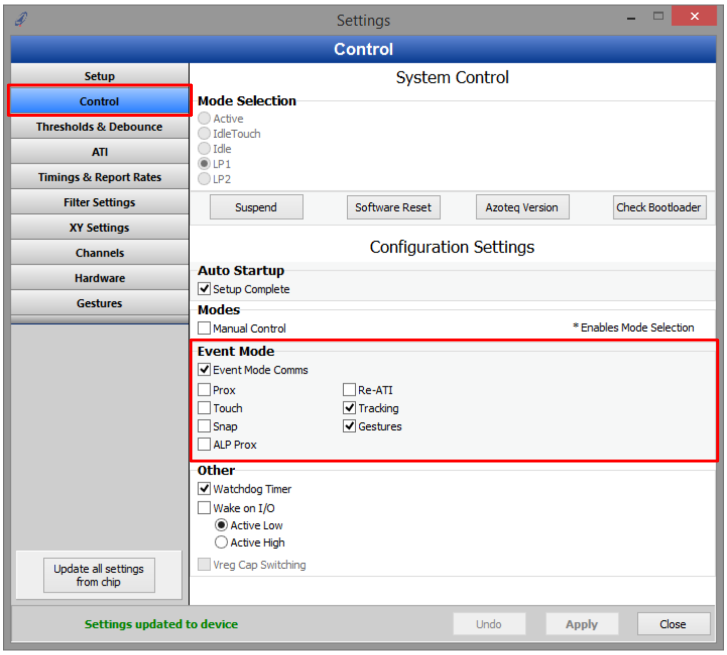
Normally the master device is only interested in communication with the IQS5xx if certain events have taken place. At other times communication is thus not necessary.

The different events that should cause I²C communication to occur can be selected on the Control sub-menu. *Prox* and *Touch* events will typically only be selected if individual touch buttons are implemented, since they trigger an event when the prox or touch status of a channel changes. *ALP Prox* could be used to trigger some backlighting or other device wake-up actions since user interaction has been detected.

Typically *tracking* events are enabled since this causes communication when the system is in *Active* mode, which is when there is tracking and movement on the trackpad. *Gesture* events are also a common option, triggering communication when a gesture is present.

If snap channels are implemented, the *snap* event is also a common addition to the events used.

For the TPS65, only gestures and tracking events are required for the master device to obtain all useful information.



Settings

Control

System Control

Mode Selection
○ Active
○ IdleTouch
○ Idle
● LP1
○ LP2

Configuration Settings

Auto Startup
☑ Setup Complete

Modes
□ Manual Control
* Enables Mode Selection

Event Mode
☑ Event Mode Comms
□ Prox
□ Touch
□ Snap
□ ALP Prox
□ Re-ATI
☑ Tracking
☑ Gestures

Other
☑ Watchdog Timer
□ Wake on I/O
● Active Low
○ Active High
□ Vreg Cap Switching

Settings updated to device

Figure 6.17 Event mode configuration

6.8.2 Forced communication in the GUI

The GUI will detect when *event mode* is active, and in that case any I²C transaction with the IQS5xx will use the forced communication method, as needed when an I²C session is not available each cycle. The master (GUI) thus starts a transaction even if RDY is low. Clock stretching is then done until the correct time to allow I²C to continue. The designer can thus use the GUI to monitor how the communication works during *event mode*.

7 Export final firmware

Once the device is correctly set up, the parameters can be used to create a new application HEX file. The GUI can export such a HEX file, and this can be programmed onto the device. With this custom firmware programmed, the device setup is correct after power-up without any interaction from the master required. The parameters are thus determined using the GUI interface, which is an easy design environment in which to obtain these settings.

7.1 Export HEX file

In the Setup sub-menu, press the Export Hex button. This will take you to a file manager window where the new HEX file can be saved. Note that the GUI will use the latest firmware file available, and insert the settings into the HEX of the device at that moment. After saving this file, the GUI will offer to program the current device with this new firmware file, which is useful to confirm the functionality of the newly created firmware file. If this file is programmed, the user will notice that you simply need to press *Start*, and then all of the settings determined will be correctly defined.

7.2 GUI synchronization with defaults

The GUI automatically synchronizes with the new default settings defined in the custom firmware file. So after pressing *Start*, all of the parameters in the GUI will display the values as defined by the firmware file.

8 GUI

With the device setup explained, a few more features of the GUI not yet covered are highlighted here.

8.1 Processing options

On slower PCs, the processing done on the GUI could be too much for the PC, causing a reduction in performance. Although this should not be a problem for most users, in order to improve this, modify the settings found at the main window menu at the top of the window under *Options -> processing options*.

8.2 Gesture demo

To view the gesture outputs, the gestures received are displayed in text on the *Gestures* section to the left of the main window.

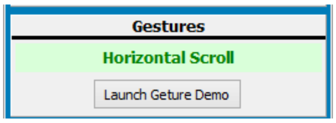


Figure 8.1 Gesture output display

However by pressing the Launch Geture Demo button you enable a special gesture display demo, which gives better feedback on gestures and performance. The demo sphere reacts to the gestures made.

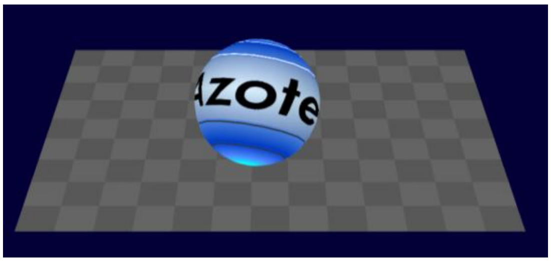


Figure 8.2 Gesture demo

Note: when performing a swipe action, the sphere is rotated / spun. The gesture swipe output initiates the rotation on the sphere, but the inertia / deceleration on the sphere is purely a display effect on the GUI side.

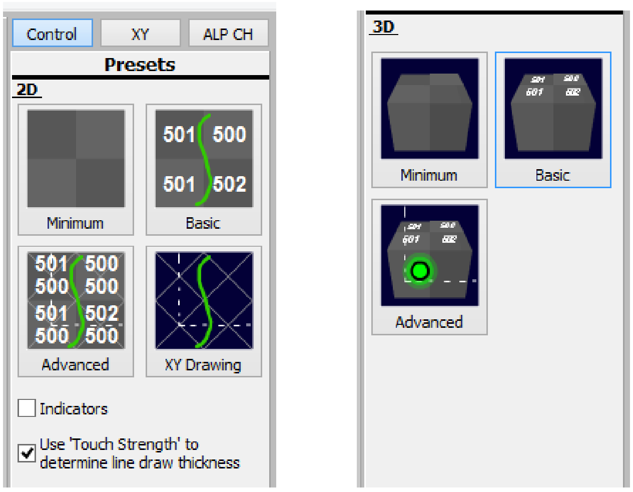
The gestures and the actions on the gesture demo are summarised in the following table.

Table 8.1 Gesture demo

Gesture	Demo response
Single tap	A single tap causes the sphere to drop and return to the same location
Press and hold	Sphere drops and remains until gesture is released
Swipe (all directions)	Swipe gestures spin/rotate the sphere
2 finger tap	2 finger taps change the colour of the sphere
Horizontal & vertical scroll	Scroll gestures move the sphere around on the screen
Zoom	Zoom gestures increase and decrease the size of the sphere

8.3 Main window display options

The trackpad outputs (prox/touch/snap/XY) can be displayed with various options on the main window. To simplify the use, a few preset configurations have been selected, which can be configured by simply pressing the preset picture/button. The different 2D and 3D presets are shown in the picture below.



□ Indicators

☑ Use 'Touch Strength' to determine line draw thickness

Figure 8.3 Display presets

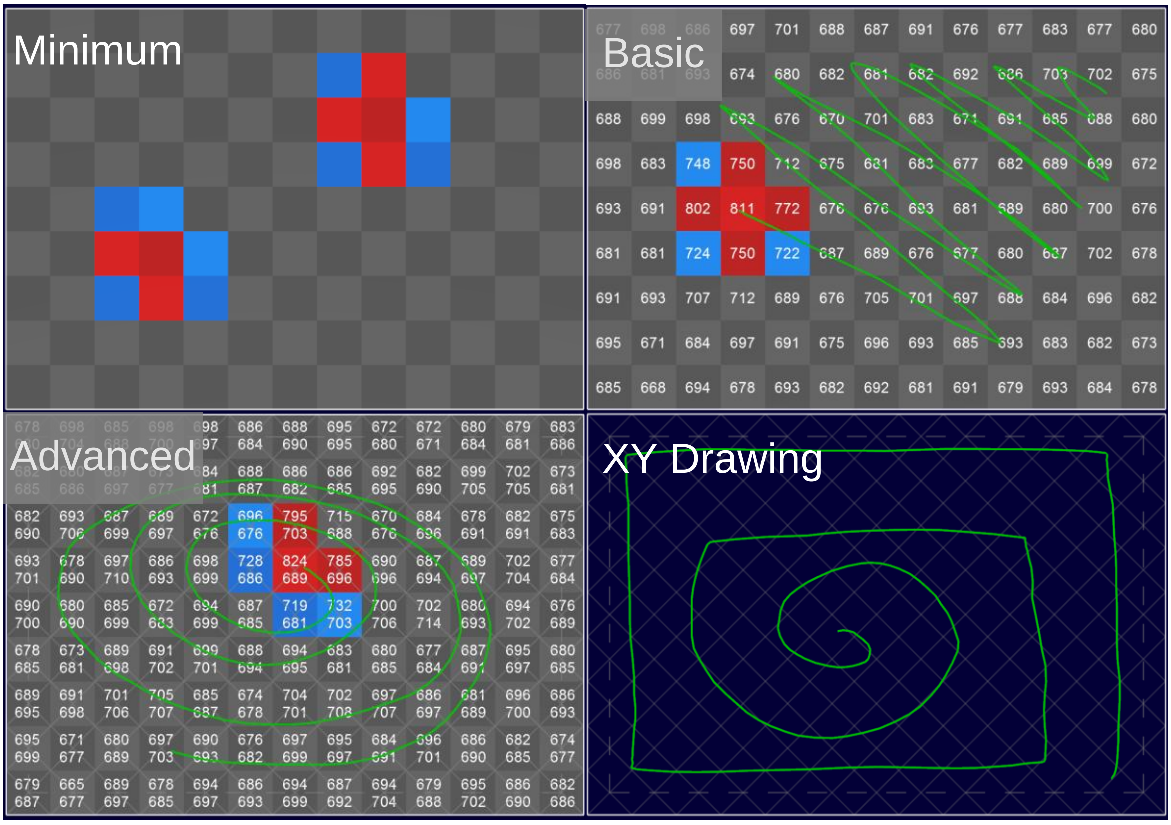


Figure 8.4 2D preset display examples

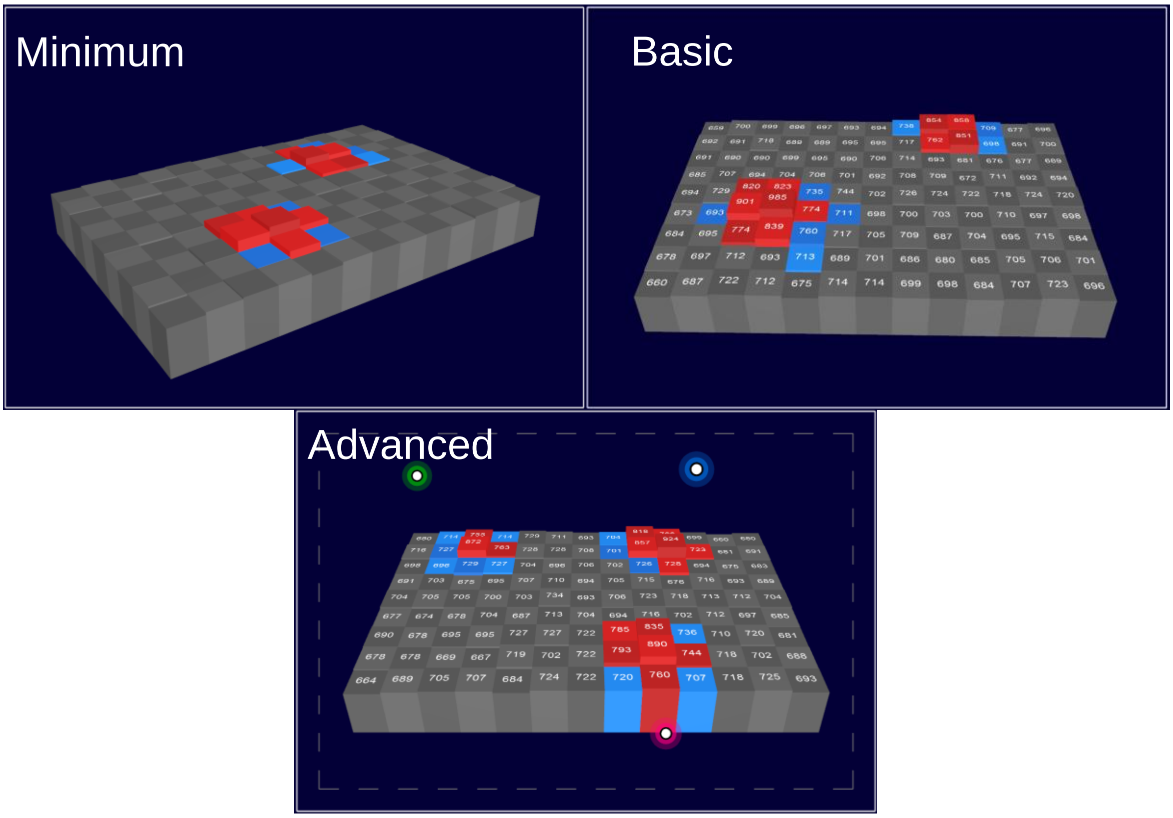


Figure 8.5 3D preset display examples

Remember when selecting certain display options, the GUI will automatically switch ON the applicable streaming data (such as count values or reference values) so that they can be displayed, which adds a lot of time to each cycle, so remember to switch this off before evaluating other aspects, or setting up timing related parameters.

Other display combinations can be manually selected by pressing the Custom Setup button at the bottom-right of the main window. Here various display options are available.

The *Show diamond grid* options will indicate where the diamond pattern is usually located relative to the outputs. By further enabling *Show active drawing area,* a dashed line will show where the active area is relative to the diamond sensors.

8.4 INI files

Similar to the IQS5xx-A000, an INI file can be saved to store the current device and GUI configuration. After power-up, the GUI will write all the INI file settings to the device for temporary setup. With the ability to program the settings permanently onto the IQS5xx-B000 using the custom firmware export functionality, the INI file will be used to a lesser degree.

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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 B2; US 7,781,980 B2; US 7,915,765 B2; US 7,994,726 B2; US 8,035,623 B2; US RE43,606 E; US 8,288,952 B2; US 8,395,395 B2; US 8,531,120 B2; US 8,659,306 B2; US 8,823,273 B2; EP 1 120 018 B2; EP 1 206 168 B1; EP 1 308 913 B1; EP 1 530 178 A1; EP 2 351 220 B1; EP 2 559 164 B1; CN 1330853; CN 1783573; AUS 761094; HK 104 1401

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