IQS7211A DATASHEET

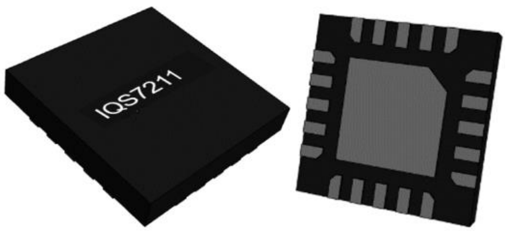
Versatile Trackpad for Low Power Wearable Application

1 Device Overview

The IQS7211 ProxFusion® IC is a sensor fusion device targeting the wearable fitness market. A low-power dedicated wake-up touch button launches full trackpad/touchscreen (up to 32 channel) sensing with best-in-class sensitivity and power consumption. Other features include automatic tuning and long-term activation with environmental tracking.

1.1 Main Features

WLCP package
Representation only



QFN package
Representation only

> Highly flexible ProxFusion® device
> 13 (QFN) / 11 (WLCSP) configurable external sensor pad connections
> Mutual/Self capacitive sensor configuration for display wake-up
> ULP wake-up on touch
- Dedicated Ultra Low Power wake-up touch sensor or
- Wake-up on display/trackpad

> Sensor flexibility
- Automatic sensor tuning for optimum sensitivity
- Internal voltage regulator
- Reference capacitor
- On-chip noise filtering
- Detection debounce and hysteresis
- Wide range of capacitance detection

> Trackpad/Touchscreen
- High resolution coordinate outputs
- Fast response: Coordinate report rate up to 100Hz
- Individual sensor touch (for up to 32 touch key applications)
- Integrated touch size output (area and strength) for touch integrity
- Gesture recognition engine
- Electrode mapping for optimal PCB layout
- Configurable coordinate resolution and orientation
- Compatible with wide range of overlay materials and thicknesses
- Compatible with multiple 1- and 2- layer sensor patterns
- Adjustable sensing frequency offset for limiting potential display interference
- No calibration required – systems automatically compensated for mechanical & temperature changes
- Water immunity features

> Design & manufacturing support
- Touch pattern layout drawing
- Full FPC layout package (example & customized)
- Test guide for touch pattern
- RFI immunity design support

- Design simplicity
  - PC Software for debugging and obtaining optimal performance
  - One-time settings programming (during MP) or pre–programmed devices
  - Auto-run from programmed settings for simplified integration
  - No production line calibration required
- Display cover lens thickness
  - Minimum thickness 0.5mm
  - Maximum thickness: 2-4mm depending on design parameters
- Base board IC placement support:
  - Up to 200mm[i] board to touch panel interface capability
- Minimize display noise
  - Advanced DSP for touch performance
  - Display and charger interference avoidance
  - Auto adjusting digital filters
- Supports different display touch panel types
  - On-cell
  - Add-on touch panel
- Supporting up to 2.5" panels
- Screen resolution:
  - 256 per channel
  - Example: 1792x768 (8x4 channels), 1280x1024 (6x5 channels)
- Automated system power modes for optimal response vs consumption
- I^2C communication interface with IRQ/RDY (up to fast plus - 1MHz)
- Event and streaming modes
- Customizable user interface due to programmable memory
- Supply Voltage 1.8V (-5%) to 3.5V
- Small packages:
  - WLCSP18 (1.62 x 1.62 x 0.5 mm) – interleaved 0.4mm x 0.6mm ball pitch
  - QFN20 (3 x 3 x 0.5 mm) – 0.4mm pitch

1.2 Applications

- Fitness Bands
- True Wireless Stereo (TWS) earbuds
- Game controller touch pads
- Headphones

[i] Based on <0.1mm track width and >25um passivation thickness with full Vss shielding

1.3 Block Diagram

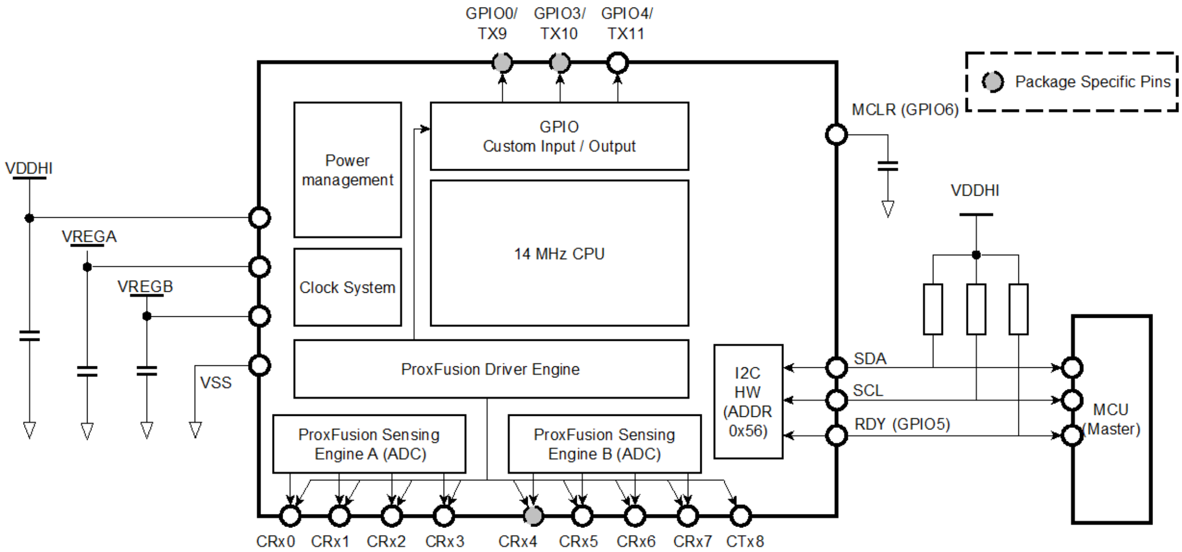
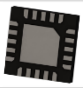


Figure 1.1 Functional Block Diagram[i]

1.4 Option Summary

Typical Sensor Configurations – QFN20

	Trackpad Square	Trackpad Rectangular
Trackpad option	6x5	8x4

Numerous other electrode combinations are supported.

Typical Sensor Configurations – WLCSP18

	Trackpad Square	Trackpad Rectangular
Trackpad option	5x5	7x3

Numerous other electrode combinations are supported.

[i] WLCSP18 packages does not have a CRx4 pin and combines GPIO0 and GPIO3

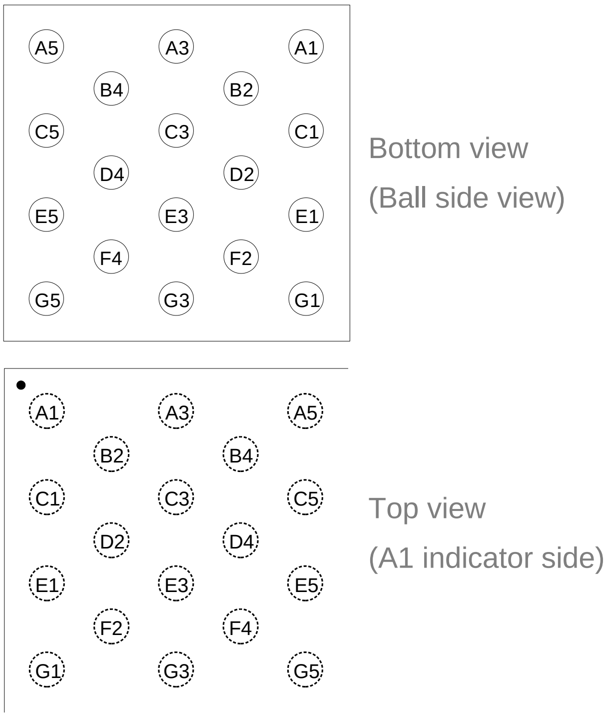
Contents

List of Abbreviations

ATI	Automatic Tuning Implementation
LTA	Long-term Average

2 Hardware Connection

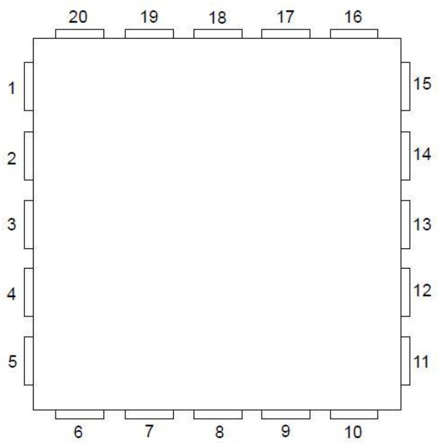
2.1 WLCSP18 Pin Diagrams



Pin no.	Signal name
A5	MCLR / GPIO6
A3	SCL / GPIO2
A1	Tx9 / Tx10 / GPIO0 / GPIO3
B4	SDA / GPIO1
B2	Tx11 / GPIO4
C5	Vdd
C3	RDY / GPIO5
C1	Tx8
D4	Vss
D2	CRx2 / Tx2
E5	VregD
E3	CRx1 / Tx1
E1	CRx6 / Tx6
F4	CRx0 / Tx0
F2	CRx5 / Tx5
G5	VregA
G3	CRx3 / Tx3
G1	CRx7 / Tx7

Figure 2.1: 18-pin WLCSP Package (Top and Bottom View)

2.2 QFN20 Pin Diagram



Pin no.	Signal name	Pin no.	Signal name
1	VDD	11	CRx6 / Tx6
2	VREGD	12	CRx7 / Tx7
3	VSS	13	Tx8
4	VREGA	14	Tx9 / GPIO0
5	CRx0 / Tx0	15	Tx10 / GPIO3
6	CRx1 / Tx1	16	Tx11 / GPIO4
7	CRx2 / Tx2	17	RDY / GPIO5
8	CRx3 / Tx3	18	SCL / GPIO2
9	CRx4 / Tx4	19	SDA / GPIO1
10	CRx5 / Tx5	20	MCLR / GPIO6

Area name	Signal name
Tab	Float

Figure 2.2: 20-pin QFN Package (Top View)

2.3 Pin Attributes

Table 2.1: Pin Attributes

Pin no.		Signal name	Signal type[i]	Buffer type	Power source	Reset state after BOR[ii]
WLCSP18	QFN20					
C5	1	VDD	Power	Power	N/A	
E5	2	VREGD	Power	Power	N/A	
D4	3	VSS	Power	Power	N/A	
G5	4	VREGA	Power	Power	N/A	
F4	5	CRx0 / Tx0	Analog		VREGA	
E3	6	CRx1 / Tx1	Analog		VREGA	
D2	7	CRx2 / Tx2	Analog		VREGA	
G3	8	CRx3 / Tx3	Analog		VREGA	
-	9	CRx4 / Tx4	Analog		VREGA	
F2	10	CRx5 / Tx5	Analog		VREGA	
E1	11	CRx6 / Tx6	Analog		VREGA	
G1	12	CRx7 / Tx7	Analog		VREGA	
C1	13	CTx8	Analog		VREGA	
A1	14	GPIO0 / Tx9	Digital/Prox		VDD/VREGA	
B4	19	SDA	Digital		VDD	
A3	18	SCL	Digital		VDD	
A1	15	GPIO3 / Tx10	Digital/Prox		VDD/VREGA	
B2	16	GPIO4 / Tx11	Digital/Prox		VDD/VREGA	
C3	17	RDY / GPIO5	Digital		VDD	
A5	20	MCLR / GPIO6	Digital		VDD	

2.4 Signal Descriptions

Table 2.2: Signal Descriptions

Function	Signal name	Pin no.		Pin type	Description
		WLCSP18	QFN16		
ProxFusion®	CRx0 / Tx0	F4	5	IO	ProxFusion® channel
	CRx1 / Tx1	E3	6	IO	
	CRx2 / Tx2	D2	7	IO	
	CRx3 / Tx3	G3	8	IO	
	CRx4 / Tx4	-	9	IO	
	CRx5 / Tx5	F2	10	IO	
	CRx6 / Tx6	E1	11	IO	
	CRx7 / Tx7	G1	12	IO	
	Tx8	C1	13	IO	
	Tx9 / GPIO0	A1	14	IO	CTx9 pad
	Tx10 / GPIO3	A1	15	IO	CTx10 pad
	Tx11 / GPIO4	B2	16	IO	CTx11 pad
	RDY / GPIO5	C3	17	IO	Input filter disabled for external clock input.
GPIO	MCLR / GPIO6	A5	20	IO	Active pulldown, 200k resistor to VDD, Pulled low during POR, and MCLR function enabled by default. VPP input for OTP
I²C	SDA / GPIO1	B4	19	IO	I²C Data
	SCL / GPIO2	A3	20	IO	I²C clock
Power	VDD	C5	1	P	Power supply input voltage
	VREGD	E5	2	P	Regulated supply input to digital
	VSS	D4	3	P	Analog/Digital Ground

[i] Signal Types: I = Input, O = Output, I/O = Input or Output

[ii] High-Z = High-impedance with Schmitt trigger and pullup or pulldown (if available) disabled

	VREGA	G5	4	P	Regulator output. Regulated supply input to internal analog circuit

2.5 Reference Schematic

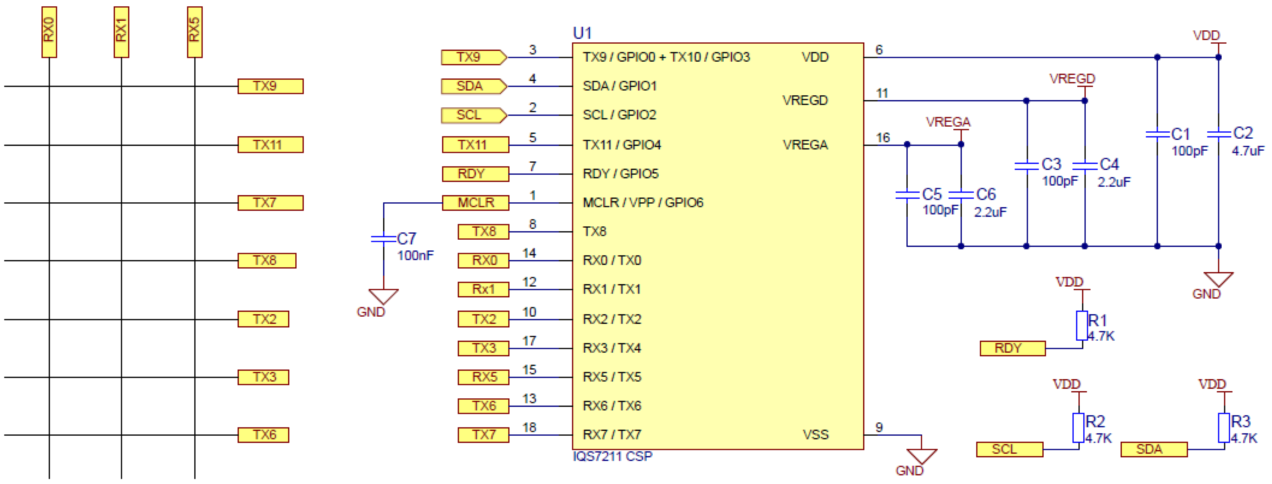


Figure 2.3 Reference Trackpad Schematic: 7x3 Pattern

3 Electrical Characteristics

3.1 Absolute Maximum Ratings

	Min	Max	Unit
Voltage applied at VDDHI pin to VSS	1.71	3.5	V
Voltage applied to any ProxFusion® pin	-0.3	VREG	V
Voltage applied to any other pin (referenced to VSS)	-0.3	VDDHI + 0.3 (3.5V max)	V
Storage temperature, T_{stg}	-40	85	ºC

3.2 ESD Ratings

			Value	Unit
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[i]	±4000	V

3.3 Recommended Operating Conditions

Recommended operating conditions		min	nom	max	Unit
VDD	Supply voltage applied at VDD pin	1.71		3.5	V
VregA	Analog-domain Regulator output at VregA	1.5	1.53	1.75	V
VregD	Digital-domain Regulator output at VregD	1.57	1.59	1.8[ii]	V
VSS	Supply voltage applied at VSS pin	0	0	0	V
T_A	Operating free-air temperature	-40	25	85	ºC
C_{VDD}	Recommended capacitor at VDD	1	2	10	µF
C_{VREGA}	Recommended external buffer capacitor at VREG, ESR≤ 200mΩ	1	2	10	µF
C_{VREGD}	Recommended external buffer capacitor at VREG, ESR≤ 200mΩ	1	2	10	µF
$Cx_{\_SELF-VSS}$	Maximum capacitance of all external electrodes on all ProxFusion® blocks (self-capacitance mode)	-	-	400	pF
$Cm_{\_CTX-CRX}$	Capacitance of all external electrodes on all ProxFusion® blocks (mutual-cap mode)	0.1	-	90	pF
$Cx_{\_CRX-VSS-1M}$	Maximum capacitance of all external electrodes on all ProxFusion® blocks (mutual-capacitance mode @f_{xfer}=1MHz)			100	pF
$Cx_{\_CRX-VSS-4M}$	Maximum capacitance of all external electrodes on all ProxFusion® blocks (mutual-capacitance mode @ f_{xfer}=4MHz sensing)			25	pF
$\frac{Cx_{CRX-VSS}}{Cm_{CTX-CRX}}$	Capacitance ratio for optimal SNR in mutual capacitance mode	10		20	n/a
$R_{Cx\_CRX/CTX}$	Series (in-line) resistance of all mutual capacitance pins (Tx & Rx pins) in mutual capacitance mode	0[iii]	0.47	10[iv]	kΩ
R_{Cx_SELF}	Series (in-line) resistance of all self capacitance pins in self capacitance mode	0[iii]	0.47	10[iv]	kΩ

3.4 Current Consumption

Power mode	Active channels	Report rate (Sampling rate) [ms]	Current [uA]
Active Mode	Trackpad – All (21 Channel)	10	1400
Idle	Trackpad – All (21 Channel)	50	200

[i] JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Pins listed as ±4000 V may actually have higher performance.

[ii] Vdd≥2V

[iii] Nominal series resistance of 470Ω is recommended to prevent received and emitted EMI effects. Typical resistance also adds additional ESD protection

[iv] Series resistance limit is a function of f_{xfer} and the circuit time constant, RC. $R_{max} \times C_{max} = 1/(6 \times f_{xfer})$ where "C" is the pin capacitance to Vss.

Low power 1	Wake-up touch – Single	100	12
Low power 2	Wake-up touch – Single	200	<4

4 Timing and Switching Characteristics

4.1 Reset Levels

		Min	Typ	Max	Unit
V_{VDDHI}	Power-up/down level (Reset trigger) – slope > 100V/s	1.040	1.353	1.568	V
V_{REG}	Power-up/down level (Reset trigger) – slope > 100V/s	0.945	1.122	1.304	V

4.2 MCLR Pin Levels and Characteristics

Table 4.1 MCLR pin characteristics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{IL(MCLR)VDD\_HI}$	MCLR Input low level voltage	Vdd = 3.3V	V_{SS}-0.3	-	1.05	V
$V_{IL(MCLR)VDD\_LOW}$	MCLR Input low level voltage	Vdd = 1.7V	V_{SS}-0.3	-	0.75	V
$V_{IH(MCLR)VDD\_HI}$	MCLR Input high level voltage	Vdd = 3.3V	2.25	-	V_{DD_HI}+0.3	V
$V_{IH(MCLR)VDD\_HI}$	MCLR Input high level voltage	Vdd = 1.7V	1.05	-	V_{DD_LOW}+0.3	V
$R_{PU(MCLR)}$	MCLR pull-up equivalent resistor		180	210	240	kΩ
$t_{PULSE(MCLR)}$	MCLR input pulse width – no trigger	Vdd = 3.3V	-	-	15	ns
$t_{PULSE(MCLR)}$	MCLR input pulse width – no trigger	Vdd = 1.7V			10	ns
$t_{TRIG(MCLR)}$	MCLR input pulse width – ensure trigger	Vdd = 3.3V, Vdd = 1.7V	250	-	-	ns

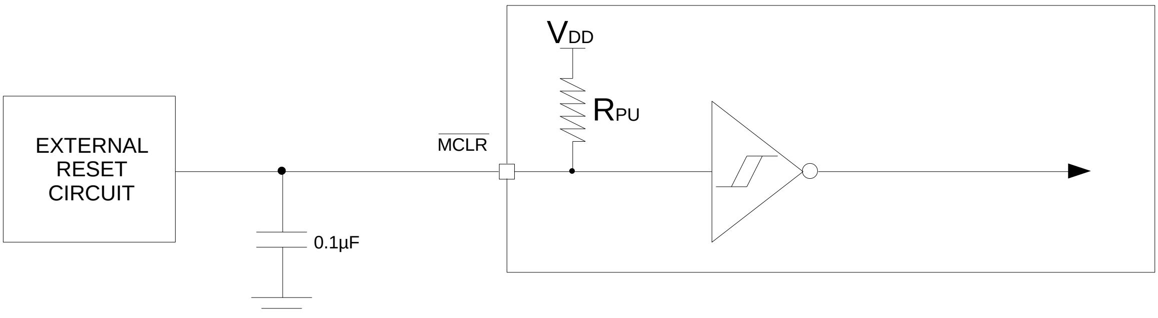


Figure 4.1 MCLR pin diagram

4.3 Miscellaneous Timings

		Min	Typ	Max	Unit
f_{xfer}	Charge transfer frequency (derived from f_{SYS})	42	500-1500	5000	kHz
f_{OSC}	Master CLK frequency tolerance 14MHz	13.23	14	14.77	MHz
f_{OSC}	Master CLK frequency tolerance 18MHz	17.1	18	19.54	MHz
t_{WDT}	Software watchdog timer period		1024		ms

4.4 Digital I/O Characteristics

		min	nom	max	Unit
V_{IL}	Input low level voltage	Vss - 0.3V		0.3 * VDDHI	V
V_{IH}	Input high level voltage	0.7 * VDDHI		VDDHI + 0.3V	V

4.5 I²C Characteristics

Specified over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted).

PARAMETER		TEST CONDITIONS	VDDHI	MIN	TYP	MAX	UNIT
f_{SCL}	SCL clock frequency		1.8V, 3.3V	1000			kHz
$t_{HD,STA}$	Hold time (repeated) START		1.8V, 3.3V	0.26			µs
$t_{SU,STA}$	Setup time for a repeated START		1.8V, 3.3V	0.26			µs
$t_{HD,DAT}$	Data hold time		1.8V, 3.3V	0			ns
$t_{SU,DAT}$	Data setup time		1.8V, 3.3V	50			ns
$t_{SU,STO}$	Setup time for STOP		1.8V, 3.3V	0.26			µs
t_{SP}	Pulse duration of spikes suppressed by input filter		1.8V, 3.3V	50			ns

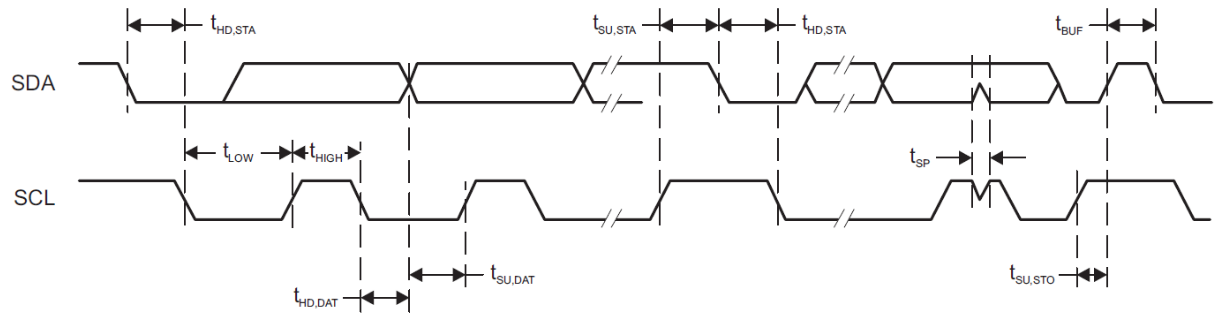


Figure 4.2: I²C Mode Timing

5 ProxFusion® Module

The IQS7211 contains a ProxFusion® module that uses patented technology to measure and process the capacitive sensor data. The channel touch output is the primary output from the sensors. These are processed further to provide secondary trackpad outputs that include finger position, finger size as well as on-chip gesture recognition.

5.1 Trackpad Channels

On a trackpad sensor (typically a diamond shape pattern), each intersection of an Rx and Tx row/column forms a projected-capacitive sensing element which is referred to as a *channel*. Each channel has an associated count value, reference value and touch status.

5.1.1 Channel Numbers

Trackpad channels are numbered from 0 to (*TotalRxs***TotalTxs*) – 1. They are assigned from the top-left corner, first along the Rxs before stepping to the next Tx. The channel number must be known for some settings such as allocating channels into sensing cycles (timeslots). Here is an example of a 4x3 trackpads' channel numbers:

Table 5.1 Channel number assignment

	Rx0 (Column 0)	Rx4 (Column 1)	Rx1 (Column 2)	Rx5 (Column 3)
Tx8 (Row 0)	0	1	2	3
Tx10 (Row 1)	4	5	6	7
Tx2 (Row 2)	8	9	10	11

5.2 Alternate Low-Power Channel (ALP)

To provide lower power consumption, LP1 and LP2 are configured to utilise a single custom sensor, instead of sensing the trackpad channels. This channel has a lot of setup flexibility:

- *Sensing method*: projected capacitive or self capacitive (SELF_OR_PROJ).
- *Multiple electrode selection*: which Rxs (RX_EN) / Txs (ALP_TX_ENABLE) are active during conversions.
- *Auto-prox*: autonomous sensing cycles while core is asleep (LPX_AUTO_PROX_CYCLES) giving further power saving, but similar wake-up capability.
- *Count value filtering* (ALP_FILTER): gives reliable proximity detection in noisy environments.
- *Single channel*: since the alternate channel is processed as only a single channel, much less processing is done, allowing for lower overall power consumption.

5.3 Count Value

The capacitive sensing measurement returns a *count value* for each channel. Count values are inversely proportional to capacitance, and all outputs are derived from this.

5.3.1 Trackpad Count Values

The individual trackpad channel count values (Count values) are unfiltered.

5.3.2 ALP Count Values

If you enable Rxs from both prox engine A and B, then there will be two count measurements (*ALP count A / B*). To reduce processing time (and this decrease current consumption) the measurements are added together (*ALP count value*) and processed as a single 'channel'.

A count value filter is implemented on this channel to give stable proximity output for system wake-up from low-power mode. It is recommended to leave this count filter enabled (*ALP_FILTER*).

The amount of filtering can be modified (*ALP count beta)* if required. This beta is used as follows to determine the damping factor of the filter:

Count damping factor = Beta / 256

If the beta is small, the filtering is stronger, and if the beta is larger, the filtering is weaker.

5.3.3 Max Count

Each channel is limited to having a count value smaller than the configurable limit (*MAX_COUNT*). If the ATI setting or hardware causes measured count values higher than this, the conversion will be stopped, and the max value will be read for that relevant count value.

5.3.4 Delta Value

The signed delta values (*Delta values*) are simply:

Delta = Count - Reference

5.4 Reference Value / Long-Term Average (LTA)

User interaction is detected by comparing the measured count values to some reference value. The reference value/LTA of a sensor is slowly updated to track changes in the environment and is not updated during user interaction.

5.4.1 Trackpad References

The trackpad *reference values* are a two-cycle averaged of the count value, stored during a time of no user activity, and thus is a non-affected reference. The trackpad reference values are only updated from LP1 and LP2 mode when modes are managed automatically, where no user interaction is assumed. Thus, if the system is controlled manually, the reference must also be managed and updated manually by the host.

The reference value is updated or refreshed according to a configurable interval (*Reference update time*), in seconds.

5.4.2 ALP Long-Term Average

The ALP channel does not have a snapshot reference value as used on the trackpad but utilises a filtered long-term average value (*ALP LTA*). The LTA tracks the environment closely for accurate comparisons to the measured count value, to allow for small proximity deviations to be sensed. The speed of LTA tracking can be adjusted with the *ALP LTA beta*. There is a beta for LP1 and LP2. This is to allow different settings for different report rates, so that the speed of LTA tracking can remain the same.

5.4.3 Reseed

Since the *Reference* (or *LTA* for ALP channel) is critical for the device to operate correctly, there could be known events or situations which would call for a manual reseed. A reseed takes the latest measured counts, and seeds the *reference/LTA* with this value, therefore updating the value to the latest environment. A reseed command can be given by setting the corresponding bit (*TP_RESEED* or *ALP_RESEED*).

5.5 Channel Outputs

5.5.1 Trackpad Touch Output

The trackpad touch output (*Touch status*) is set when a channels' count value increases by more than the selected threshold.

The touch threshold for a specific channel is calculated as follows:

Threshold = Reference x (1 + *Multiplier* / 128)

where *Multiplier* is an 8-bit unsigned value for both the 'set' and 'clear' threshold, allowing a hysteresis to provide improved touch detection. A smaller fraction will thus be a more sensitive threshold.

5.5.2 ALP Output

This output (*ALP_OUTPUT*) is set when a channels' count value deviates from the LTA value by more than the selected threshold - thus a delta setting (*ALP threshold*). This can be used to implement a proximity or touch detection, depending on the threshold used.

5.5.3 Output Debounce

There is no debounce on the touch detection (or release). This is because debouncing adds too much delay, and fast movements on the touch panel cannot be debounced fast enough to provide reliable XY output data.

Debounce on the ALP output is however done, to allow for stable proximity detection if needed. An 8-bit unsigned value is used for the set and clear debounce parameter (*ALP set/clear debounce*).

5.6 Auto Tuning Implementation (ATI)

The ATI is a sophisticated technology implemented in the new ProxFusion® devices to allow optimal performance of the devices for a wide range of sensing electrode capacitances, without modification to external components. The ATI settings allow tuning of various parameters.

The main advantage of the ATI is to balance out small variations between trackpad hardware and IQS7211 variation, to give similar performance across devices and temperature.

For a detailed description of ATI, please see the application note.

5.6.1 ATI Course Divider / Multiplier

The *ATI course divider / multiplier* can be used to configure the base value for the trackpad (and ALP channel). The trackpad channels all use the same global parameter. The divider is a 5-bit setting (0-31) and the multiplier a 4-bit setting (0-15).

5.6.2 ATI Fine Divider

The *ATI fine divider* is also used to configure the trackpad and ALP base value. The trackpad channels also use the same global parameter. The divider is a 5-bit setting (0-31).

5.6.3 ATI Compensation (and ATI Target)

The ATI Compensation value for each channel (*ATI compensation* / *ALP ATI Compensation*) is set by the ATI procedure, and are chosen so that each count value is close to the selected target value (*ATI target* / *ALP ATI target*). The algorithm is queued using *TP_REATI / ALP_REATI*.

The *TP_REATI / ALP_REATI* bits clear automatically on chip when the algorithm has completed.

The queued Re-ATI routine will execute as soon as the corresponding channels are sensed. For example, the TP_REATI when the system is in Active, Idle-Touch or Idle mode, and the ALP_REATI when the system is in LP1 or LP2.

The ALP channel has individual compensation values (*ALP ATI compensation*) for both proximity engines A (Rx0-3) and B (Rx4-7).

The ALP ATI target value applies to each of the individual count values configured for the ALP channel. The combined channel will thus have a count near the sum of the ATI target.

This routine will only execute after the communication window is terminated, and the I^2C communication will only resume once the ATI routine has completed.

ATI compensation is 10-bit value, thus 0 to 1023.

5.6.4 ATI Compensation Divider

The ATI Compensation can be scaled by means of the *ATI compensation divider*. Since the 'size' of compensation is scaled, a small divider value will relate to large compensation, meaning the step size of each compensation unit increase will be larger. For smaller more accurate compensation steps, a larger divider is selected, but the 'range' of compensation is then reduced.

5.7 Automatic Re-ATI

5.7.1 Description

When enabled (*REATI_EN* or *ALP_REATI_EN*) a Re-ATI will be triggered if certain conditions are met. One of the most important features of the Re-ATI is that it allows easy and fast recovery from an incorrect ATI, such as when performing ATI during user interaction with the sensor. This could cause the wrong ATI Compensation to be configured, since the user affects the capacitance of the sensor. A Re-ATI would correct this. It is recommended to always have this enabled.

When a Re-ATI is performed on the IQS7211, a status bit will set momentarily to indicate that this has occurred (*REATI_OCCURRED* / *ALP_REATI_OCCURRED*).

5.7.2 Conditions for Re-ATI to activate

1. **Reference drift**

A Re-ATI is performed when the reference of a channel drifts outside of the acceptable range around the ATI Target.

The boundaries where Re-ATI occurs for the trackpad channels and for the ALP channels are independently set via the drift threshold value (*Reference drift limit* / *ALP LTA drift limit*). The Re-ATI boundaries are calculated from the delta value as follows:

Re-ATI Boundary = ATI target ± Drift limit

For example, assume that the ATI target is configured to 800 and that the reference drift value is set to 50. If Re-ATI is enabled, the ATI algorithm will be repeated under the following conditions:

Reference > 850 or Reference < 750

The ATI algorithm executes in a short time, so goes unnoticed by the user.

2. Decreased count value

A considerable decrease in the count value of a channel is abnormal since user interaction increases the count value. Therefore, if a decrease larger than the configurable threshold (*Minimum count Re-ATI delta)* is seen on such a channel, it is closely monitored. If this is continuously seen for 15 cycles, it will trigger a Re-ATI.

5.7.3 ATI Error

After the ATI algorithm is performed, a check is done to see if there was any error with the algorithm. An ATI error is reported if one of the following is true for any channel after the ATI has completed:

> ATI Compensation = 0 (min value)
> ATI Compensation >= 1023 (max value)
> Count is already outside the Re-ATI range upon completion of the ATI algorithm.

If any of these conditions are met, the corresponding error flag will be set (*ATI_ERROR* / *ALP_ATI_ERROR*). The flag status is only updated again when a new ATI algorithm is performed.

Re-ATI will not be repeated immediately if an ATI Error occurs. A configurable time (*Re-ATI retry time*) will pass where the Re-ATI is momentarily suppressed. This is to prevent the Re-ATI repeating indefinitely. An ATI error should however not occur under normal circumstances.

6 Sensing Modes

The IQS7211 automatically switches between different charging modes dependent on user interaction and other aspects. This is to allow for fast response, and low power consumption when applicable. The current mode can be read from the device (*CHARGING_MODE*).

The modes are best illustrated by means of the following state diagram.

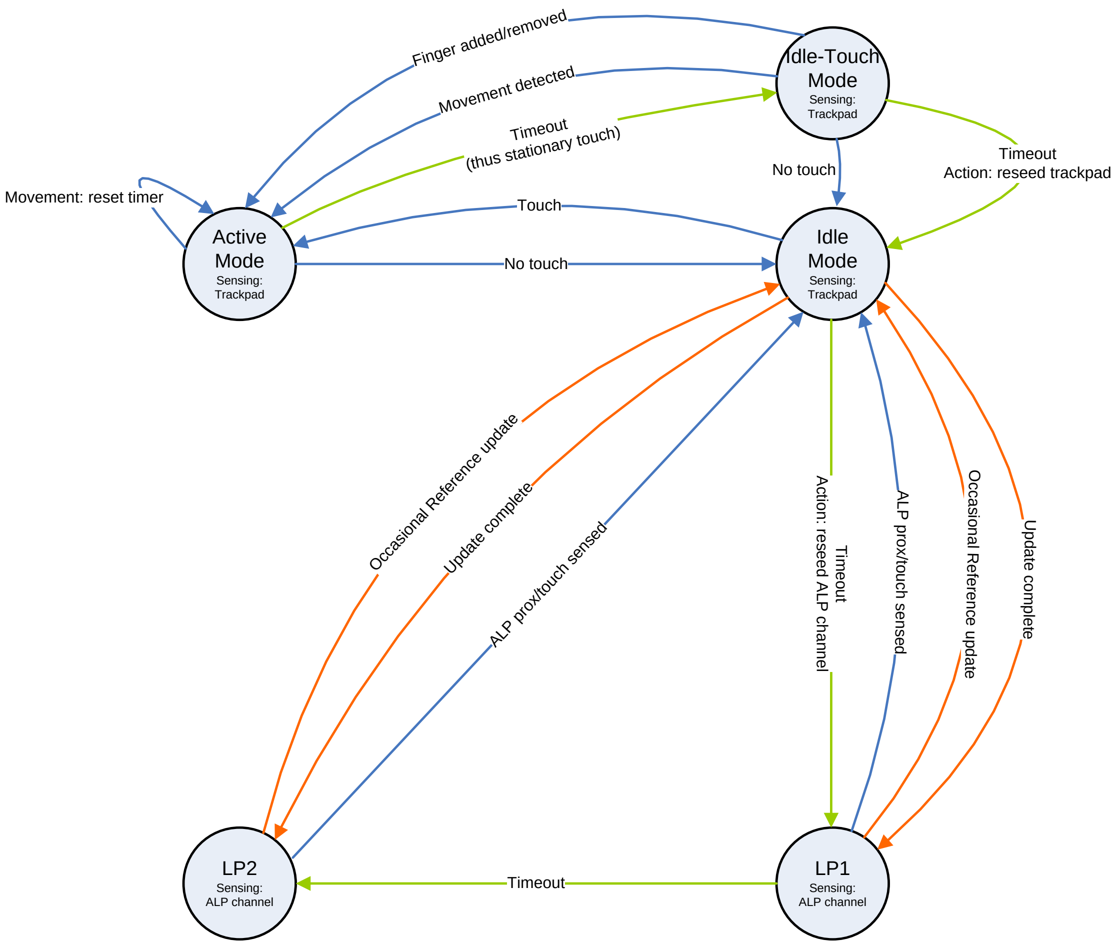


Figure 6.1 System Mode State Diagram

6.1 Report Rate

The report rate for each mode can be adjusted as required by the design. A faster report rate will have a higher current consumption but will give faster response to user interaction. *Active mode* typically has the fastest report rate, and the other modes are configured according to the power budget of the design, and the expected response time.

The report rate is configured by selecting the cycle time (in milliseconds) for each mode:

> *Report rate Active mode*
> *Report rate Idle touch mode*
> *Report rate Idle mode*
> *Report rate LP1 mode*
> *Report rate LP2 mode*

6.2 Mode Timeout

The timeout values can be configured, and once these times have elapsed, the system will change to the next state according to the state diagram.

These times are adjusted by selecting a desired value (in seconds), for the specific timeout:

- > *Timeout - Active mode*
- > *Timeout - Idle touch mode*
- > *Timeout - Idle mode*
- > *Timeout - LP1 mode*

A timeout value of 0 will result in a 'never' timeout condition.

6.3 Manual Control

The default method allows the IQS7211 to automatically switch between modes and update reference values as shown in Figure 6.1. This requires no interaction from the master to manage the device.

The master can manage various states and implement custom power modes when *Manual Control* is enabled (*MANUAL_CONTROL*). The master needs to control the mode (*MODE_SELECT*), and also manage the reference values by reseeding (*TP_RESEED*) or manually writing to the reference registers (*Reference values*).

7 Trackpad

7.1 Configuration

7.1.1 Size Selection

The total number of Rx and Tx channels used for trackpad purposes must be configured (*Total Rx* / *Total Tx*). This gives a rectangular area of channels, formed by rows and columns of Rx and Tx sensors.

7.1.2 Cycle Setup

The trackpad channels need to be packed into cycles. The Azoteq PC GUI can be used to assist with this setup. Each cycle can simultaneously sense one channel from Prox block A (Rx0-3) and one from Prox block B (Rx4-7). They must be for the same Tx, and the channel numbers are packed into the cycle numbers (*Cycle allocation registers*) accordingly. A value of 255 for the channel number indicates *no conversion* is allocated.

It is best to select the Rxs as the even numbered sensors, so that optimal cycles/timeslot usage occurs. Similarly, a balanced number of sensors from A and B are optimal.

7.1.3 Trackpad / Cycle Size Limitations

This product is limited to 32 channels, and 18 cycles. Any trackpad size that fits into these limits are possible to implement.

Table 7.1 Trackpad configurations using 12 electrodes

Total Rxs	Total Txs	Channels	Timeslots	Possible?
1	11	11	11	☑
2	10	20	10	☑
3	9	27	18	☑
4	8	32	16	☑
5	7	35	21	☒
6	6	36	18	☒
7	5	35	20	☒

8	4	32	16	☑

7.1.4 Individual Channel Disabling

If the sensor is not a complete rectangle (this could be due to mechanical cut-outs or trackpad shape), there will be some channels that fall within the *Total Rx* / *Total Tx* rectangle but do not exist. They must simply not be allocated to a sensing cycle (see 7.1.2). The channel numbers are however still allocated for the complete rectangle (see Section 5.1.1).

7.1.5 Rx / Tx Mapping

The Rxs and Txs of the trackpad can be assigned to the trackpad in any order to simplify PCB layout and design. The Rx/Tx mapping configures which actual Rx and Tx electrodes are used for the trackpad. The Rxs are specified first, up until the number of Rxs as defined by the *Total Rx*, then the Txs follow immediately.

Following the example in Table 5.1, the RxTxMapping settings will be as follows:

RxTxMapping[0] = 0
RxTxMapping[1] = 4
RxTxMapping[2] = 1
RxTxMapping[3] = 5
RxTxMapping[4] = 8
RxTxMapping[5] = 10
RxTxMapping[6] = 2
RxTxMapping[7..12] = n/a

7.2 Trackpad Outputs

The channel count variation (deltas) and touch status outputs are used to calculate finger location data.

7.2.1 Number of Fingers

This gives an indication of the number of active finger inputs on the trackpad (*Number of fingers*).

7.2.2 Relative XY

If there is only one finger active, a *Relative X* and *Relative Y* value is available. This is a signed 2's complement 16-bit value. It is a delta of the change in X and Y, in the scale of the selected output resolution.

Note: Gestures also use these registers to indicate swipe, scroll and zoom parameters.

7.2.3 Absolute XY

For all the multi-touch inputs, the absolute finger position (*Absolute X/Y*), in the selected resolution (*Resolution X/Y*) of the trackpad, is available.

7.2.4 Touch Strength

This value (*Touch strength*) indicates the strength of the touch by giving a sum of all the deltas associated with the finger, and therefore varies according to the sensitivity setup of the sensors.

7.2.5 Area

The number of channels associated with a finger is provided here. This area is usually equal to or smaller than the number of touch channels under the finger.

7.2.6 Tracking / Identification

The fingers are tracked from one cycle to the next, and the same finger will be in the same position in the memory map. The memory location thus identifies the finger.

7.3 Max Number of Multi-touches

The maximum number of allowed multi-touches is configurable (*Max multi-touches*) up to 2 points. If more than the selected value is sensed, a flag is set (*TOO_MANY_FINGERS*) and the XY data is cleared.

7.4 XY Resolution

The output resolution for the X and Y coordinates are configurable (*X/Y Resolution*). The on-chip algorithms use 256 points between each row and column. The resolution is defined as the total X and total Y output range across the complete trackpad.

7.5 Stationary Touch

A stationary touch is defined as a point that does not move outside of a certain boundary within a specific time. This movement boundary or threshold can be configured (*Stationary touch movement threshold*) and is defined as a movement in either X or Y in the configured resolution.

The device will switch to *Idle-Touch* mode when a stationary point is detected for the active mode timeout period, where a lower duty cycle can be implemented to save power in applications where long touches are expected.

If movement is detected, a status flag (*TP_MOVEMENT*) is set.

7.6 Multi-touch Finger Split

The position algorithm looks at areas (polygons) of touches and calculates positional data from this. Two fingers near each other could have areas touching, which would merge them incorrectly into a single point. A finger split algorithm is implemented to separate these merged polygons into multiple fingers. There is a *Finger split factor* which can be adjusted to determine how aggressive this finger splitting must be implemented. A value of '0' will not split polygons, and thus merge any fingers with touch channels adjacent (diagonally also) to each other.

7.7 XY Output Flip & Switch

By default, X positions are calculated from the first column to the last column. Y positions are by default calculated from the first row to the last row. The X and/or Y output can be flipped (*FLIP_X* / *FLIP_Y*), to allow the [0, 0] co-ordinate to be defined as desired. The X and Y axes can also be switched (*SWITCH_XY_AXIS*) allowing X to be the Txs, and Y to be along the Rxs. *Note: The channel numbers are still assigned the same way, first along the Rxs, then to the next Tx, it is not affected by this setting.*

7.8 XY Position Filtering

Stable XY position data is available due to two on-chip filters, namely the Moving Average (MAV) filter, and the Infinite Impulse Response (IIR) filter. The filters are applied to the raw positional data. It is recommended to keep both filters enabled for optimal XY data.

7.8.1 MAV Filter

If enabled (*MAV_FILTER*), raw XY points from the last two cycles are averaged to give the filter output.

7.8.2 IIR Filter

The IIR filter, if enabled (*IIR_FILTER*), can be configured to select between a dynamic and a static filter (*IIR_SELECT*).

The damping factor is calculated from the selected *Beta* as follows:

Damping factor = Beta / 256

7.8.2.1 Dynamic Filter

Relative to the speed of movement of a co-ordinate, the filter dynamically adjusts the amount of filtering (damping factor) performed. When fast movement is detected, and quick response is required, less filtering is done. Similarly, when a co-ordinate is stationary or moving at a slower speed, more filtering can be applied.

The damping factor is adjusted depending on the speed of movement. Three of these parameters are adjustable to fine-tune the dynamic filter if required (*XY dynamic bottom beta* / *XY dynamic lower speed* / *XY dynamic upper speed*).

The speed is defined as the distance (in the selected resolution) travelled in one cycle (pixels/cycle).

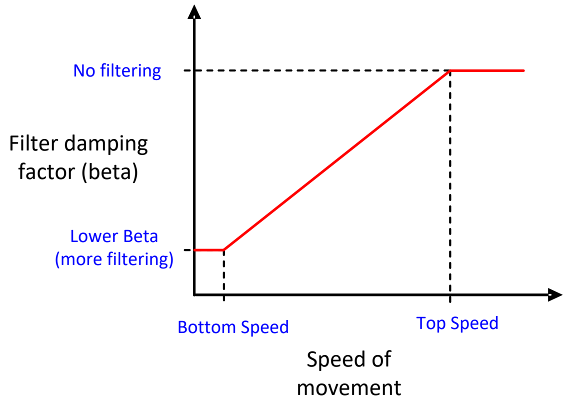


Figure 7.1 Dynamic Filter Parameters

7.8.2.2 Static Filter

Co-ordinates filtered with a fixed but configurable damping factor (*XY static beta*) are obtained when using the static filter (*IIR_STATIC*). It is recommended that the dynamic filter is used due to the advantages of a dynamically changing damping value.

7.9 X and Y Trim

Due to boundary conditions at the edges of the trackpad, it is unlikely that the X and Y extreme values will be achievable (0 and X/Y Resolution). To be able to achieve this, the edges can be trimmed with configurable amount (*X Trim* / *Y Trim*) on-chip. For example, say *X Trim* is set to 0, and a finger on the left of the trackpad gives a minimum X output of 48, and a maximum of 960 (for X resolution set to 1000). Then an X Trim = 50 could be used to trim away the 'dead' area, and the full 0 to 1000 range will be achievable.

8 Gestures

The following on-chip gestures are available:

> 1 finger gestures (Gestures):
- A single tap
- A press and hold

- Swipe X+
- Swipe X-
- Swipe Y+
- Swipe Y-

Each single finger gesture can individually be enabled and disabled by setting or clearing the corresponding bits in the register Gesture Enable.

All gestures are calculated relative to their starting coordinates, i.e., the first coordinate at which the touch was detected. Furthermore, if at any time during a gesture, more than the required number of touches is detected, the gesture will be invalidated.

8.1 Single Tap

The single tap gesture requires that a touch is made and released in the same location and within a short period of time. Some small amount of movement from the initial coordinate must be allowed to compensate for shift in the finger coordinate during the release. This bound is defined in register *Tap distance*, which specifies the maximum deviation in pixels the touch can move before a single tap gesture is no longer valid.

Similarly, the *Tap time* register defines the maximum duration (in ms) that will result in a valid gesture. That is, the touch should be released before the time in *Tap time* is reached.

A valid single tap gesture will be reported (*SINGLE_TAP*) in the same processing cycle as the touch release was detected and will be cleared on the next cycle. No movement will be reported in the relative XY registers (*Relative X* and *Relative Y*) during this gesture.

Since the gesture reports after the finger is removed, the location of the tap gesture is placed in the *Absolute X/Y* registers of finger 1 at this time. With *Number of fingers* set to 0, this will not look like an active finger, and is just a repetition of the location of the tap that has occurred for the main controller to utilise.

8.2 Press and Hold

The same register that defines the bounds for the single tap gesture (*Tap distance*) is used for the press and hold gesture. If the touch deviates more than the specified distance, the gesture is no longer valid.

However, if the touch remains within the given bound for longer that the period (in ms), defined as the sum of the register values in *Tap time* and *Hold time*, a press and hold gesture will be reported (*PRESS_AND_HOLD*). The gesture will continue to be reported until the touch is released or if a second touch is registered.

No data will be reported in *Relative X* and *Relative Y* before the defined maximum hold period is reached, however, the relative data will be reported thereafter. This allows for features such as drag-n-drop.

8.3 Swipe (X-, X+, Y-, Y+)

All four swipe gestures work in the same manner and are only differentiated in their direction. The direction is defined with respect to the origin (0, 0) of the trackpad (Channel 0). If the touch is moving away from the origin, it is considered a positive swipe (+) and if it is moving towards the origin, it is a negative swipe (-). Whether the swipe is of the type X or Y is defined by which axis the touch is moving approximately parallel to.

A swipe gesture event is only reported when a moving touch meets all three of the following conditions:

1. A minimum distance is travelled from its initial coordinates, as defined in pixels by the value in registers *Swipe x distance* and *Swipe y distance.*
2. The distance in (1) is covered within the time specified in *Swipe time* (in ms).
3. The angle of the swipe gesture, as determined by its starting coordinate and the coordinate at which conditions (1) and (2) were first met, does not exceed the threshold in *Swipe angle* with regards to at least 1 of the axes. The value in register *Swipe angle* is calculated as $64 \tan \theta$, where θ is the desired angle (in degrees).

The respective swipe gesture will be reported for 1 cycle (*SWIPE_X-, X+, Y- Y+*) when all these conditions are met. The relative distance travelled will be reported in registers *Relative X* and *Relative Y* throughout.

8.4 Switching Between Gestures

For all single finger gestures, it is necessary to release all touches before any new gesture can be made and validated.

9 Hardware Settings

Settings specific to hardware and the ProxFusion® Module charge transfer characteristics can be changed.

Below some are described, the other hardware parameters are not discussed as they should only be adjusted under guidance of Azoteq support engineers.

9.1 Main Oscillator

The main oscillator frequency can be configured to 14MHz or 18MHz (*14MHz_18MHz*). Smaller adjustments to incrementally decrease the main oscillator can be made (*MAIN_OSC_ADJ*).

9.2 Charge Transfer Frequency

The charge transfer frequency (f_{cc}) can be configured using the product GUI, and the relative parameters (*Conversion frequency*) will be provided. For high resistance sensors (such as ITO), it might be needed to decrease f_{cc}.

9.3 Reset

9.3.1 Reset Indication

After a reset, the *SHOW_RESET* bit will be set by the system to indicate the reset event occurred. This bit will clear when the master sets the *ACK_RESET*, if it becomes set again, the master will know a reset has occurred, and can react appropriately.

9.3.2 Software Reset

The IQS7211 can be reset by means of an I^{2}C command (*SW_RESET*).

9.3.3 Hardware Reset

The MCLR/GPIO6 pin (active LOW) can be used to reset the device. For more details see Section 4.2.

10 Additional Features

10.1 Setup Defaults

The supplied GUI can be utilised to configure the optimal settings. The design specific firmware is exported by the GUI and programmed onto the device. These parameters are used as the default values after start-up, without requiring any setup from the master.

Two bytes (*Settings version number*) are available so that the designer can label and identify the user selected default start-up settings. This allows the master to verify if the device firmware has the intended configuration as required.

10.2 Automated Start-up

The device is programmed with the application firmware, bundled with settings specifically configured for the current hardware as described in Section 10.1. After power-up the device will automatically use the settings and perform the configuration/setup accordingly.

Please note that the device will remain in a setup I^2C loop until the *Settings version number* is set. This allows devices that have no pre-programmed defaults to remain in the setup window until all parameters are configured over I^2C. Once this is done the settings version number can be written, and the system will move to the automated start-up procedure. It is recommended for production that the settings are integrated into the device HEX file programmed onto it.

10.3 Watchdog Timer (WDT)

A software watchdog timer is implemented to improve system reliability.

The working of this timer is as follows:

> A software timer t_{WDT} is linked to the LFTMR (Low frequency timer) running on the "always on" Low Frequency Oscillator (10 kHz).
> This timer is reset at a strategic point in the main loop.
> Failing to reset this timer will cause the appropriate ISR (interrupt service routine) to run.
> This ISR performs a software triggered POR (Power on Reset).
> The device will reset, performing a full cold boot.

10.4 RF Immunity

The IQS7211 has immunity to high power RF noise. To improve the RF immunity, extra decoupling capacitors are suggested on V_{REG} and V_{DDHI}.

Place a 100pF in parallel with the 1uF ceramic on V_{REG}. Place a 1uF ceramic on V_{DDHI}. All decoupling capacitors should be placed as close as possible to the V_{DDHI} and V_{REG} pads.

If needed, series resistors can be added to Rx electrodes to reduce RF coupling into the sending pads. Normally these are in the range of 470Ω-1kΩ.

PCB ground planes also improve noise immunity.

10.5 Additional Non-Trackpad Channels

Unused projected capacitance channels can be used to design additional buttons or sliders. Note that the channels will still provide XY data output, which can be ignored (or utilised) by the master.

10.6 Bootloader

tbc

10.7 Version Information

tbd

11 I²C Interface

11.1 I²C Module Specification

The device supports a standard two wire I²C interface with the addition of a RDY (ready interrupt) line. The communications interface of the IQS7211 supports the following:

> Fast-mode-plus standard I2C up to 1MHz.
> Streaming data as well as event mode.
> The provided interrupt line (RDY) is an open-drain active low implementation and indicates a communication window.

The IQS7211 implements 8-bit addressing with 2 bytes of data at each address. Two consecutive read/writes are required in this memory map structure. The two bytes at each address will be referred to as "byte 0" (least significant byte) and "byte 1" (most significant byte).

11.2 I²C Address

The default 7-bit device address is 0x56 ('1010110'). The full address byte will thus be 0xAD (read) or 0xAC (write).

Other address options exist on special request. Please contact Azoteq.

11.3 I³C Compatibility

This device is not compatible with an I³C bus due to clock stretching allowed for data retrieval.

11.4 Memory Map Addressing

11.4.1 8-bit address

Most of the memory map implements an 8-bit addressing scheme for the required user data. For all application requirements this should be adequate.

11.4.2 Extended 16-bit Address

For development purposes larger blocks of data (such as the trackpad 16bit channel count values) are found in an extended 16-bit memory addressable location. It is possible to only address each Block as an 8-bit address, and then continue to clock into the next address locations. For example, address 0xE000 is where the trackpad count values are located. If you thus do the following, you will read the count values from address 0xE000 to 0xE003:

START → S_ADR(W) → 0xE0 (addr high-byte) → REPEAT-START → S_ADR(R) → DATA @ 0xE0000 → DATA @ 0xE001 → DATA @ 0xE002 → DATA @ 0xE003 → STOP

However, if you need to address a specific byte in that extended memory map space, then you will need to address using the full 16-bit address (note the 16bit address is high byte first, unlike the data which is low byte first):

START → S_ADR(W) → 0xE0 (addr high-byte) → 0x03 (addr low-byte) → REPEAT-START → S_ADR(R) → DATA @ 0xE003 →

11.5 Data

The data is 16-bit words, meaning that each address obtains 2 bytes of data. For example, address 0x10 will provide two bytes, then the next two bytes read will be from address 0x11.

The 16-bit data is sent in little endian byte order (least significant byte first).

11.6 I²C Timeout

If the communication window is not serviced within the *I²C timeout* period (in milliseconds), the session is ended (RDY goes HIGH), and processing continues as normal. This allows the system to continue and keep reference values up to date even if the master is not responsive, however the corresponding data was missed/lost, and this should be avoided.

11.7 Terminate Communication

A standard I²C STOP ends the current communication window.

11.8 RDY / IRQ

The communication has an open-drain active-LOW RDY signal to inform the master that updated data is available. It is optimal for the master to use this as an interrupt input and obtain the data accordingly. It is also useful to allow the master MCU to enter low-power/sleep allowing wake-up from the touch device when user presence is detected.

11.9 Event Mode Communication

The device can be set up to bypass the communication window when no activity is sensed (*EVENT_MODE*). This is usually enabled since the master does not want to be interrupted unnecessarily during every cycle if no activity occurred. The communication will resume (RDY will indicate available data) if an enabled event occurs. It is recommended that the RDY be placed on an interrupt-on-pin-change input on the master.

11.9.1 Events

Numerous events can be individually enabled to trigger communication, they are:

> Trackpad events (*TP_EVENT*): event triggered if there is a change in X/Y value, or if a finger is added or removed from the trackpad.
> Touch events (*TP_TOUCH_EVENT*): event only triggers if a channel has a change in a touch state. This is mostly aimed at channels that are used for traditional buttons, where you want to know only when a status is changed.
> Re-ATI (*REATI_EVENT*): one communication cycle is given to indicate the Re-ATI occurred (*REATI_OCCURRED* / *ALP_REATI_OCCURRED)*.
> Proximity/Touch on ALP (*ALP_EVENT*): event given on state change.

11.9.2 Force Communication / Polling

The master can initiate communication even while RDY is HIGH (inactive). The default method is that the IQS7211 will clock stretch until an appropriate time to complete the I²C transaction. The master firmware will not be affected (if clock stretching is correctly handled).

If the associated clock stretching cannot be allowed, then an alternative comms request method can be enabled (*COMMS_REQUEST_EN*). To achieve this, the master will do communication when RDY is not active (thus forcing comms), and it will write a comms request to the device. This comms request is as follows:

START → S_ADR(W) → 0xFF (comms request) → Any byte → Any byte → STOP

After this request for communication has been sent, then the next available communication window will become available as normal (thus RDY going LOW).

For optimal program flow, it is suggested that RDY is used to sync on new data. The forced/polling method is only recommended if the master must perform I^2C and *Event Mode* is active.

12 I²C Memory Map

12.1 Register Addresses

Table 12.1 Memory Map

Address	Data (16bit)	Notes
0x00 – 0x0B	Version details	See 1.1
0x10	Info flags	See Table 12.2
0x11	Gestures	See Table 12.3
0x12	Relative X (pixels)	See 7.2.2
0x13	Relative Y (pixels)	
0x14	Finger 1 X-coordinate (pixels)	See 7.2.3
0x15	Finger 1 Y-coordinate (pixels)	
0x16	Finger 1 touch strength	See 7.2.4
0x17	Finger 1 area	See 7.2.5
0x18	Finger 2 X-coordinate (pixels)	See 7.2.3
0x19	Finger 2 Y-coordinate (pixels)	
0x1A	Finger 2 touch strength	See 7.2.4
0x1B	Finger 2 area	See 7.2.5
0x20	Touch status <0>	See Table 12.4
0x21	Touch status <1>	
0x22	Touch status <2>	
0x23	ALP channel count	See 5.3.2
0x24	ALP channel LTA	See 5.4.2
0x25	ALP count A	See 5.3.2
0x26	ALP count B	See 5.3.2
0x30	Trackpad ATI multiplier/dividers (Global)	See Table 12.5 & 5.6.1
0x31	Trackpad ATI compensation divider (Global)	See 5.6.4
0x32	Trackpad ATI target	See 5.6.3
0x33	Trackpad reference drift limit	See 5.7.2
0x34	Trackpad minimum count Re-ATI value	
0x35	Re-ATI retry time (s)	See 5.7.3
0x36	ALP ATI multiplier/dividers	See Table 12.5 & 5.6.1
0x37	ALP ATI compensation divider	See 5.6.4
0x38	ALP ATI target	See 5.6.3
0x39	ALP LTA drift limit	See 5.7.2

0x3A	ALP ATI Compensation A		See 5.6.3
0x3B	ALP ATI Compensation B		
0x40	Active Mode report rate (ms)		See 6.1
0x41	Idle-Touch Mode report rate (ms)		
0x42	Idle Mode report rate (ms)		
0x43	LP1 Mode report rate (ms)		
0x44	LP2 Mode report rate (ms)		
0x45	Active Mode timeout (s)		See 6.2
0x46	Idle-Touch Mode timeout (s)		
0x47	Idle Mode timeout (s)		
0x48	LP1 Mode timeout (s)		
0x49	Reference update time (s)		See 5.4.1
0x4A	I^2C timeout (ms)		See 11.6
0x50	System Control		See Table 12.6
0x51	Config Settings		See Table 12.7
0x52	Other Settings		See Table 12.8
0x53	Touch clear threshold	Touch set threshold	See 5.5.1
0x54	ALP threshold		See 5.5.2
0x55	open		~
0x56	ALP clear debounce	ALP set debounce	See 5.5.3
0x57	open		
0x58	Trackpad conversion frequency		See Table 12.9 and 9.1
0x59	ALP conversion frequency		
0x5A	Trackpad hardware settings		See Table 12.10
0x5B	ALP hardware settings		
0x60	Total Rxs	Trackpad settings	See Table 12.11 and 7.1.1
0x61	Max Multi-touches	Total Txs	See 7.3 and 7.1.1
0x62	X resolution		See 7.4
0x63	Y resolution		
0x64	XY dynamic filter – bottom speed (pixels)		See 7.8.2.1
0x65	XY dynamic filter – top speed (pixels)		
0x66	Static filter beta value	Dynamic filter bottom beta	See 7.8.2.2 and 7.8.2.1
0x67	Finger split factor	Stationarly touch movement threshold	See 7.6 and 7.5
0x68	X trim value		
0x69	Y trim value		

0x70	ALP count filter beta		Fraction of 256
0x71	LP2 beta ($1/2^x$)	LP1 beta ($1/2^x$)	
0x72	ALP setup		See Table 12.12
0x73	ALP Tx enable		See Table 12.13
0x74	Settings major version	Settings minor version	See Section 10.1
0x80	Gesture enable		See Table 12.14
0x81	Tap time		(milliseconds)
0x82	Tap distance		(pixels)
0x83	Hold time		(milliseconds)
0x84	Swipe time		(milliseconds)
0x85	Swipe x-distance		(pixels)
0x86	Swipe y-distance		(pixels)
0x87	Swipe angle		64tan(deg)
0x90	RxTx mapping <1..0>		*See Section XX for Rx/Tx mapping details
0x91	RxTx mapping <3..2>		
0x92	RxTx mapping <5..4>		
0x93	RxTx mapping <7..6>		
0x94	RxTx mapping <9..8>		
0x95	RxTx mapping <11..10>		
0x96	RxTx mapping <13..12>		
	(HIGH byte)	(LOW byte)	
0xA0	1st channel for cycle-0	0x05	Allocation of channels into cycles (sensing timeslots). See 7.1.2
0xA1	0x05	2nd channel for cycle-0	
0xA2	2nd channel for cycle-1	1st channel for cycle-1	
0xA3	1st channel for cycle-2	0x05	
0xA4	0x05	2nd channel for cycle-2	
0xA5	2nd channel for cycle-3	1st channel for cycle-3	
0xA6	1st channel for cycle-4	0x05	
0xA7	0x05	2nd channel for cycle-4	
0xA8	2nd channel for cycle-5	1st channel for cycle-5	
0xA9	1st channel for cycle-6	0x05	
0xAA	0x05	2nd channel for cycle-6	
0xAB	2nd channel for cycle-7	1st channel for cycle-7	
0xAC	1st channel for cycle-8	0x05	
0xAD	0x05	2nd channel for cycle-8	
0xAE	2nd channel for cycle-9	1st channel for cycle-9	
	(HIGH byte)	(LOW byte)	

0xB0		1st channel for cycle-10	0x05	
0xB1		0x05	2nd channel for cycle-10	
0xB2		2nd channel for cycle-11	1st channel for cycle-11	
0xB3		1st channel for cycle-12	0x05	
0xB4		0x05	2nd channel for cycle-12	
0xB5		2nd channel for cycle-13	1st channel for cycle-13	
0xB6		1st channel for cycle-14	0x05	
0xB7		0x05	2nd channel for cycle-14	
0xB8		2nd channel for cycle-15	1st channel for cycle-15	
0xB9		1st channel for cycle-16	0x05	
0xBA		0x05	2nd channel for cycle-16	
0xBB		2nd channel for cycle-17	1st channel for cycle-17	
0xE0*	...	Trackpad count values		See 5.3.1
0xE1*	...	Trackpad reference values		See 5.4.1
0xE2*	...	Trackpad delta values		See 5.3.4
0xE3*	...	Trackpad ATI Compensation values		See 5.6.3

*This is extended memory map section.

12.2 Register Definitions

Table 12.2 Info Flags

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
~	ALP_ OUTPUT	~	TOO_ MANY_ FINGERS	~	TP_ MOVEMENT	NO_OF_FINGERS		SHOW_ RESET	ALP_ REATI_ OCCURRED	ALP_ ATI_ ERROR	REATI_ OCCURRED	ATI_ ERROR	CHARGING_MODE		

- Bit 15: Unused
- Bit 14: **ALP_OUTPUT:** Prox/Touch detection status of ALP channel
  - 0 = No output detected
  - 1 = Proximity/touch detected
- Bit 13: Unused
- Bit 12: **TOO_MANY_FINGERS:** Total finger status
  - 0 = Number of fingers are within the max selected value
  - 1 = Number of fingers are more than the max selected
- Bit 11: Unused
- Bit 10: **TP_MOVEMENT:** Activity or movement on trackpad status
  - 0 = No finger or no movement of fingers on trackpad
  - 1 = Movement of finger(s) seen on trackpad
- Bit 9-8: **NO_OF_FINGERS:** Number of active fingers on the trackpad (0-2)
- Bit 7: **SHOW_RESET**: Indicates a reset
  - 0 = Reset indication has been cleared by host, writing to 'Ack Reset' bit

- 1 = Reset has occurred, and indication has not yet been cleared by host

> Bit 6: **ALP_REATI_OCCURRED:** Alternate Low Power channel Re-ATI status
- 0 = No Re-ATI
- 1 = Re-ATI has just completed on the alternate LP channel

> Bit 5: **ALP_ATI_ERROR:** Alternate Low Power channel ATI error status
- 0 = Most recent ATI process was successful
- 1 = Most recent ATI process had errors

> Bit 4: **REATI_OCCURRED:** Trackpad Re-ATI status
- 0 = No Re-ATI
- 1 = Re-ATI has just completed on the trackpad

> Bit 3: **ATI_ERROR:** Error condition seen on latest trackpad ATI procedure
- 0 = Most recent ATI process was successful
- 1 = Most recent ATI process had errors

> Bit 2-0: **CHARGING_MODE:** Indicates current mode
- 000 = Active mode
- 001 = Idle-Touch mode
- 010 = Idle mode
- 011 = LP1 mode
- 100 = LP2 mode

Table 12.3 Gestures

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
~	~	~	~	~	~	~	~	~	~	SWIPE_ Y-	SWIPE_ Y+	SWIPE_ X+	SWIPE_ X-	PRESS_ AND_ HOLD	SINGLE_ TAP

> Bit 15-6: Unused

> Bit 5: **SWIPE_Y-:** Swipe in negative Y direction status
- 0 = No gesture
- 1 = Swipe in negative Y-direction occurred

> Bit 4: **SWIPE_Y+:** Swipe in positive Y direction status
- 0 = No gesture
- 1 = Swipe in positive Y-direction occurred

> Bit 3: **SWIPE_X+:** Swipe in positive X direction status
- 0 = No gesture
- 1 = Swipe in positive X-direction occurred

> Bit 2: **SWIPE_X-:** Swipe in negative X direction status
- 0 = No gesture
- 1 = Swipe in negative X direction occurred

> Bit 1: **PRESS_AND_HOLD:** Press and hold gesture status
- 0 = No gesture
- 1 = Press and hold occurred

> Bit 0: **SINGLE_TAP:** Single tap gesture status
- 0 = No gesture
- 1 = Single tap occurred

Table 12.4 Touch Status <Z>

Touch Status <0>															
Bit15	**Bit14**	**Bit13**	**Bit12**	**Bit11**	**Bit10**	**Bit9**	**Bit8**	**Bit7**	**Bit6**	**Bit5**	**Bit4**	**Bit3**	**Bit2**	**Bit1**	**Bit0**
Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch9	Ch8	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0
Touch Status <1>															
Bit15	**Bit14**	**Bit13**	**Bit12**	**Bit11**	**Bit10**	**Bit9**	**Bit8**	**Bit7**	**Bit6**	**Bit5**	**Bit4**	**Bit3**	**Bit2**	**Bit1**	**Bit0**
~	~	Ch29	Ch28	Ch27	Ch26	Ch25	Ch24	Ch23	Ch22	Ch21	Ch20	Ch19	Ch18	Ch17	Ch16
Touch Status <2>															
Bit15	**Bit14**	**Bit13**	**Bit12**	**Bit11**	**Bit10**	**Bit9**	**Bit8**	**Bit7**	**Bit6**	**Bit5**	**Bit4**	**Bit3**	**Bit2**	**Bit1**	**Bit0**
~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~

*See Section 5.1.1 for channel number assignment.

Table 12.5 Trackpad and ALP ATI Multiplier/Dividers

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
~	~	FINE_DIV					COURSE_MULT				COURSE_DIV				

- Bit 15-14: Unused
- Bit 13-9: **FINE_DIV:** Fine divider (1-31)
- Bit 8-5: **COURSE_MULT:** Course Multiplier (1-15)
- Bit 4-0: **COURSE_DIV:** Course Divider (1-31)

Table 12.6 System Control

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
~	~	~	~	~	~	SW_ RESET	~	ACK_ RESET	ALP_ REATI	TP_ REATI	ALP_ RESEED	TP_ RESEED	MODE_SELECT		

- Bit 15-10: Unused
- Bit 9: **SW_RESET:** Reset the device
  - 0 = nothing
  - 1 = Reset the device after the communication window terminates
- Bit 8: Unused
- Bit 7: **ACK_RESET**: Acknowledge a reset
  - 0 = nothing
  - 1 = Acknowledge the reset by clearing *SHOW_RESET* bit
- Bit 6: **ALP_REATI:** Queue a Re-ATI on the ALP channel
  - 0 = nothing
  - 1 = Perform Re-ATI when ALP channel is sensed again

> Bit 5: **TP_REATI:** Queue a Re-ATI on the trackpad channels
- 0 = nothing
- 1 = Perform Re-ATI when trackpad channels are sensed again

> Bit 4: **ALP_RESEED:** Reseed alternate low power channel
- 0 = nothing
- 1 = reseed the LTA of the alternate LP channel

> Bit 3: **RESEED:** Reseed trackpad channels
- 0 = nothing
- 1 = Reseed reference values of trackpad

> Bit 2-0: **MODE_SELECT:** Select mode (only applies in *Manual Mode*)
- 000 = Active mode
- 001 = Idle-Touch mode
- 010 = Idle mode
- 011 = LP1 mode
- 100 = LP2 mode

Table 12.7 Config Settings

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
~	TP_ TOUCH_ EVENT	ALP_ EVENT	~	REATI_ EVENT	TP_ EVENT	GESTURE_ EVENT	EVENT_ MODE	MANUAL_ CONTROL	~	WDT	COMMS_ REQUEST _EN	ALP_ REATI_ EN	REATI_ EN	~	~

> Bit 15: Unused

> Bit 14: **TP_TOUCH_EVENT:** Enable touch triggering event
- 0 = Toggle of touch status does not trigger an event
- 1 = Toggle of touch status triggers an event

> Bit 13: **ALP_EVENT:** Enable alternate LP channel detection triggering event
- 0 = Toggle of alternate channel prox/touch status does not trigger an event
- 1 = Toggle of alternate channel prox/touch status triggers an event

> Bit 12: Unused

> Bit 11: **REATI_EVENT:** Enable Re-ATI generating an event
- 0 = Re-ATI occurring does not trigger an event
- 1 = Re-ATI occurring triggers an event

> Bit 10: **TP_EVENT:** Enable trackpad events
- 0 = Trackpad actions will not trigger event
- 1 = Trackpad actions trigger event

> Bit 9: **GESTURE_EVENT:** Enable gesture events
- 0 = Gestures will not trigger event
- 1 = Gestures will trigger event

> Bit 8: **EVENT_MODE:** Enable event mode communication
- 0 = I^2C is presented each cycle (except auto-prox cycles)
- 1 = I^2C is only initiated when an enabled event occurs

> Bit 7: **MANUAL_CONTROL:** Override automatic mode switching
- 0 = Modes are automatically controlled by firmware
- 1 = Manual control of modes are handled by host

> Bit 6: Unused

> Bit 5: **WDT:** Watchdog timer enable/disable
  - 0 = Watchdog is disabled
  - 1 = Watchdog is enabled

> Bit 4: **COMMS_REQUEST_EN:** Set alternative polling method (while RDY not LOW)
  - 0 = Forcing comms will clock stretch until a comms window
  - 1 = A comms window must be requested with a command (no stretching)

> Bit 3: **ALP_REATI_EN:** Enable/Disable automatic Re-ATI on alternate LP channel
  - 0 = Re-ATI is disabled for alternate LP channel
  - 1 = Re-ATI is enabled for alternate LP channel

> Bit 2: **REATI_EN:** Enable/Disable automatic Re-ATI on trackpad
  - 0 = Re-ATI is disabled for trackpad channels
  - 1 = Re-ATI is enabled for trackpad channels

> Bit 1-0: Unused

Table 12.8 Other Settings

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
CAL_CH_SELECT								CAL_CAP_SIZE			14MHZ_ 18MHZ	MAIN_OSC_ADJ			

> Bit 15-8: **CAL_CH_SELECT:** Select trackpad channel for calibration cap connection (255 for disabled)

> Bit 7-5: **CAL_CAP_SIZE:** Select size of calibration cap (setting * 0.5pF)

> Bit 4: **14MHZ_18MHZ:** Main oscillator selection
  - 0 = Main oscillator is 14MHz
  - 1 = Main oscillator is 18MHz

> Bit 3-0: **MAIN_OSC_ADJ:** Small main oscillator adjustment setting (0 is no adjustment, 15 is max adjustment).

Table 12.9 Charge-Transfer Conversion Frequency

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Frequency fraction value								Up / Pass length							

*Use Azoteq product GUI to help determine these parameters

Table 12.10 Trackpad and ALP Hardware Settings

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
~	CS_0V5_ DISCHARGE	RF_ FILTER	CS_CAP_ SEL	OPAMP_BIAS		MAX_COUNT		LP2_AUTO_PROX_ CYCLES (only in ALP register)			LP1_AUTO_PROX_ CYCLES (only in ALP register)			INIT_ DELAY	

> Bit 15: Unused

> Bit 14: **CS_0V5_DISCHARGE:** Select internal Cs discharge voltage
  - 0 = Discharge to 0V (recommended for most cases)
  - 1 = Discharge to 0.5V

> Bit 13: **RF_FILTER:** Enable internal RF filters
  - 0 = RF filters disabled
  - 1 = RF filters enabled

> Bit 12: **CS_CAP_SEL:** Select internal pool capacitor size
- 0 = Internal capacitor is 40pF
- 1 = Internal capacitor is 80pF (recommended)

> Bit 11-10: **OPAMP_BIAS:** Projected opamp bias setting
- 00 = 2uA
- 01 = 5uA
- 10 = 7uA
- 11 = 10uA

> Bit 9-8: **MAX_COUNT:** Count upper limit (count value stops conversion after reaching this)
- 00 = 1023
- 01 = 2047
- 10 = 4095
- 11 = 16384

> Bit 7-5: **LP2_AUTO_PROX_CYCLES:** Select number of LP2 auto-prox cycles
- 000 = 4
- 001 = 8
- 010 = 16
- 011 = 32
- 1xx = Auto-prox disabled

> Bit 4-2: **LP1_AUTO_PROX_CYCLES:** Select number of LP1 auto-prox cycles
- 000 = 4
- 001 = 8
- 010 = 16
- 011 = 32
- 1xx = Auto-prox disabled

> Bit 1-0: **INIT_DELAY:** Initial cycles delay
- 00 = 4
- 01 = 16
- 10 = 32
- 11 = 64

Table 12.11 Trackpad Settings

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Total Rxs								~	~	MAV_ FILTER	IIR_ STATIC	IIR_ FILTER	SWITCH_ XY_AXIS	FLIP_Y	FLIP_X

> Bit 15-8: **Total Rxs** used for trackpad

> Bit 7-6: Unused

> Bit 5: **MAV_FILTER:** Enable moving averaging filter
- 0 = MAV filter on touch position disabled
- 1 = XY MAV filter on touch position enabled (recommended)

> Bit 4: **IIR_STATIC:** Select the IIR filtering method for the XY data points
- 0 = Damping factor for IIR filter is dynamically adjusted relative to XY movement (recommended)
- 1 = Damping factor for IIR filter is fixed

> Bit 3: **IIR_FILTER:** Enable IIR filter
- 0 = XY IIR filter disabled
- 1 = XY IIR filter enabled (recommended)

> Bit 2: **SWITCH_XY_AXIS:** Switch X and Y axes
- 0 = Rxs are arranged in trackpad columns (X), and Txs in rows (Y)
- 1 = Txs are arranged in trackpad columns (X), and Rxs in rows (Y)

> Bit 1: **FLIP_Y:** Flip Y output values
- 0 = Keep default Y values
- 1 = Invert Y output values

> Bit 0: **FLIP_X:** Flip X output values
- 0 = Keep default X values
- 1 = Invert X output values

Table 12.12 ALP Setup

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
~	~	~	~	~	~	ALP_ FILTER	SELF_ OR_ PROJ	Rx7_EN	Rx6_EN	Rx5_EN	Rx4_EN	Rx3_EN	Rx2_EN	Rx1_EN	Rx0_EN

> Bit 15-10: Unused

> Bit 9: **ALP_FILTER:** Enable ALP count filter
- 0 = ALP count value is unfiltered
- 1 = ALP count filter enabled

> Bit 8: **SELF_OR_PROJ:** Select ALP sensing method
- 0 = ALP is setup for self-capacitive sensing
- 1 = ALP is setup for projected-capacitive sensing

> Bit 7-0: **RX_EN:** Enable ALP Rx electrodes
- 0 = Rx disabled (not used for ALP)
- 1 = Rx enabled (forms part of ALP sensor)

Table 12.13 ALP Tx enable

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
~	~	~	Tx12_EN	Tx11_EN	Tx10_EN	Tx9_EN	Tx8_EN	Tx7_EN	Tx6_EN	Tx5_EN	Tx4_EN	Tx3_EN	Tx2_EN	Tx1_EN	Tx0_EN

> Bit 15-13: Unused

> Bit 12-0: **TX_EN:** Enable ALP Tx electrodes
- 0 = Tx disabled (not used for ALP)
- 1 = Tx enabled (forms part of ALP sensor)

Table 12.14 Gesture Enable

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
~	~	~	~	~	~	~	~	~	~	SWIPE_ Y-	SWIPE_ Y+	SWIPE_ X+	SWIPE_ X-	PRESS _AND_ HOLD	SINGLE _TAP

> Bit 15-6: Unused

> Bit 5: **SWIPE_Y-:** Swipe in negative Y direction

- 0 = Gesture disabled
- 1 = Gesture enabled

> Bit 4: **SWIPE_Y+:** Swipe in positive Y direction
- 0 = Gesture disabled
- 1 = Gesture enabled

> Bit 3: **SWIPE_X+:** Swipe in positive X direction
- 0 = Gesture disabled
- 1 = Gesture enabled

> Bit 2: **SWIPE_X-:** Swipe in negative X direction
- 0 = Gesture disabled
- 1 = Gesture enabled

> Bit 1: **PRESS_AND_HOLD:** Press and hold gesture
- 0 = Gesture disabled
- 1 = Gesture enabled

> Bit 0: **SINGLE_TAP:** Single tap gesture
- 0 = Gesture disabled
- 1 = Gesture enabled

13 Applications, Implementation and Layout

NOTE

Information in the following Applications section is not part of the Azoteq component specification, and Azoteq does not warrant its accuracy or completeness. Azoteq's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

13.1 Layout Fundamentals

13.1.1 Power Supply Decoupling

Azoteq recommends connecting a combination of a 4.7-µF plus a 100-pF low-ESR ceramic decoupling capacitor to the VDDHI and VSS pins. Higher-value capacitors may be used but can impact supply rail ramp-up time. Decoupling capacitors must be placed as close as possible to the pins that they decouple (within a few millimeters).

13.1.2 Transient Signal Management

During power up, power down, and device operation, VDDHI must not exceed the absolute maximum ratings. Exceeding the specified limits may cause malfunction of the device.

13.1.3 ProxFusion® Peripheral

This section provides a brief introduction to the ProxFusion® technology with examples of PCB layout and performance from a design kit. Please contact Azoteq for more details on design variables not covered here.

13.1.4 VREG

The VREG-A pin requires a 2.2-µF capacitor and VREG-D pin requires a 2.2-µF capacitor to regulate the LDO internal to the device. This capacitor must be placed as close as possible to the microcontroller. The figure below shows an example layout where the capacitor is placed close to the IC.

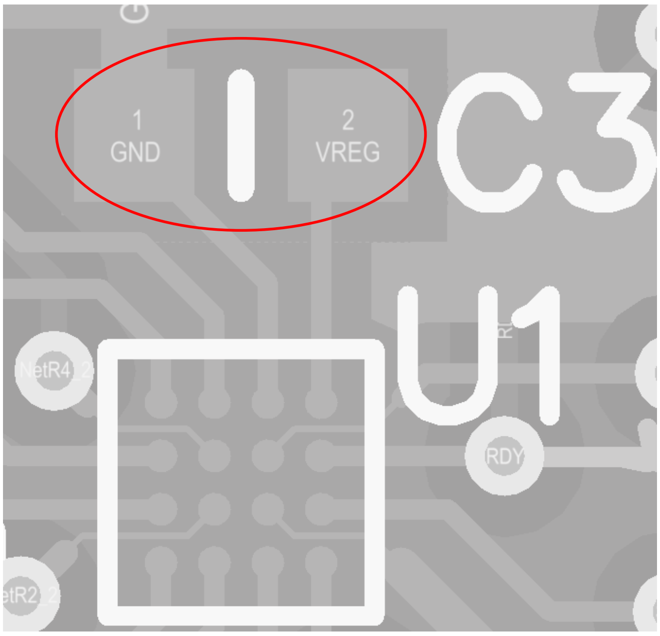


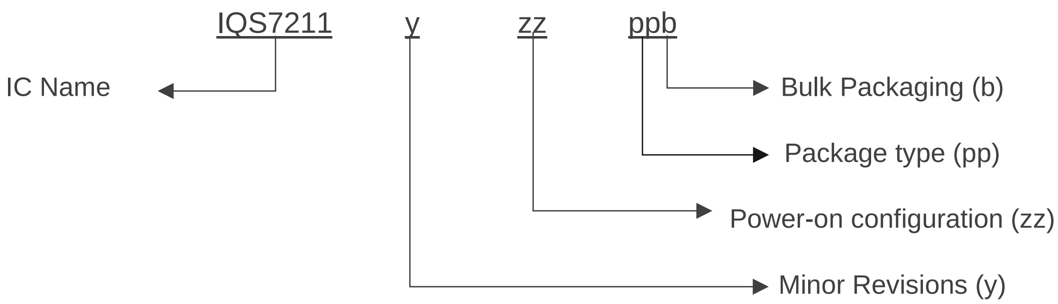
Figure 13.1: VREG Capacitor Placement Close to IC

13.1.5 ESD Protection

Typically, the laminate overlay provides several kilovolts of breakdown isolation to protect the circuit from ESD strikes. More ESD protection can be added with a series resistor placed on each channel used. A value of 470 Ω is recommended.

14 Ordering Information

Please check stock availability with your local distributor.



IC NAME	IQS7211	=	IQS7211
MINOR PRODUCT REVISION	y	=	**A** (default)
POWER-ON CONFIGURATION	zz	=	**00 (I²C with initialize settings requirement)** **zz (With power on settings – MOQs apply)**
PACKAGE TYPE	QN CS	= =	QFN20 package WLCSP-18 package
BULK PACKAGING	R	= =	Reel (3000pcs/reel) – MOQ = 3000pcs MOQ = 1 reel (orders shipped as full reels)

Figure 14.1 Order Code Description

15 Package Specification

15.1 Package Outline Description – WLCSP18

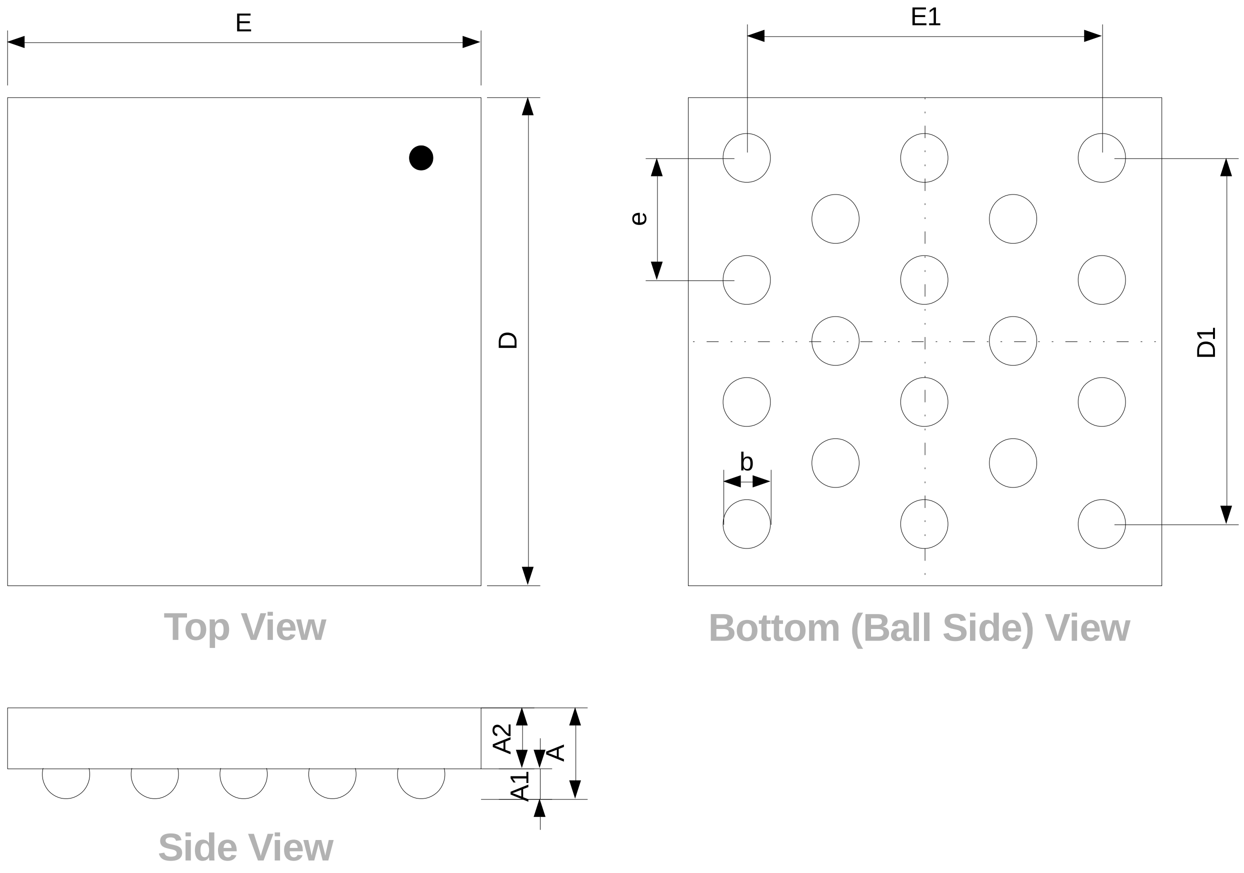


Figure 15.1 WLCSP (1.62x1.62)–18 Package outline visual description

Table 15.1 WLCSP (1.62x1.62)–18 Package outline dimensions

Dimension	[mm]	Dimension	[mm]
A	0.525±0.05	D1	1.2
A1	0.2±0.02	E	1.620±0.015
A2	0.3±0.025	E1	1.2
b	0.260±0.39	e	0.4
D	1.620±0.015		

15.2 Package Outline Description – QFN20

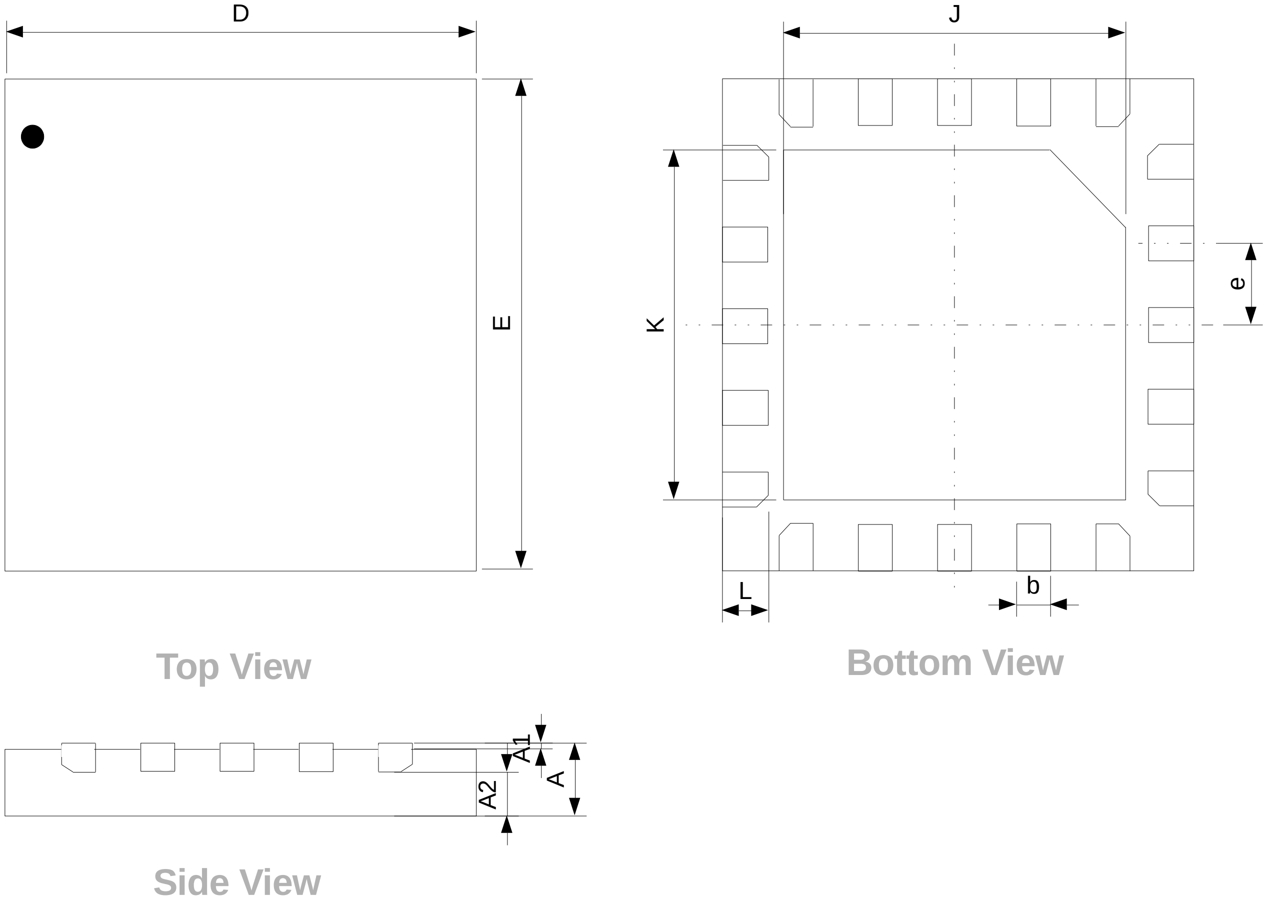


Figure 15.2 QFN(3x3)–20 Package outline description

Dimension	[mm]	Dimension	[mm]
A	0.5±0.1	E	3
A1	0.035±0.05	e	0.4
A2	0.3	J	1.7±0.1
A3	0.203	K	1.7±0.1
b	0.2±0.05	L	0.4±0.05
D	3		

Figure 15.3 QFN(3x3)–20 Package outline description

15.3 Moisture Sensitivity Levels

Contact Azoteq.

15.4 Reflow Specifications

Contact Azoteq

	USA	Asia	South Africa
Physical Address	6507 Jester Blvd Bldg 5, suite 510G Austin TX 78750 USA	Rm 1227, Glittery City Shennan Rd Futian District Shenzhen, 518033 China	1 Bergsig Avenue Paarl 7646 South Africa
Postal Address	6507 Jester Blvd Bldg 5, suite 510G Austin TX 78750 USA	Rm 1227, Glittery City Shennan Rd Futian District Shenzhen, 518033 China	PO Box 3534 Paarl 7620 South Africa
Tel	+1 512 538 1995	+86 755 8303 5294 ext 808	+27 21 863 0033
Fax	+1 512 672 8442		+27 21 863 1512
Email	info@azoteq.com	info@azoteq.com	info@azoteq.com

Visit www.azoteq.com

for a list of distributors and worldwide representation.