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IQS213A Datasheet

IQSwitch® - ProxSense® Series

3-Channel Capacitive Touch/Swipe Function Controller

Overview

Unparalleled Features

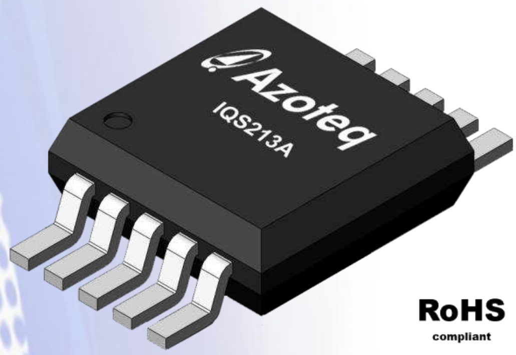
- Sub 5µA* current consumption ("Zero-Power" electronic switch).
- **I**nternal **C**apacitor **I**mplementation (ICI) – Reference capacitor on-chip
- **A**utomatic **T**uning **I**mplementation (**ATI**) - Automatic tuning for optimal operation in various environments & compensation against sensitivity reducing objects
- **IQS213A** advised for applications with high load-capacitances and high sensitivity requirements.

The **IQS213A** ProxSense® IC is a fully integrated two or three channel capacitive swipe function sensor with market leading sensitivity and automatic tuning of the sense electrodes. The **IQS213A** provides a minimalist implementation requiring few external components, with OTP-option settings and an I^2C-compatible interface that allow configuration for numerous applications.

Main Features

- 2 or 3 Channel (Projected or Self Capacitance) Input device
- Swipe Function or Differentiated Touch and Distributed Proximity Electrode Implementation
- Variable User Interface with Adjustable Swipe Function Configuration
- Auto-Off and Advanced Auto-Off Warning Function
- Supply voltage: 1.8V to 3.6V
- Internal voltage regulator and reference capacitor
- Advanced on-chip digital signal processing
- OTP (One Time Programmable) options available
- Stand-Alone GPIO (Default) / I^2C compatible interface
- Low Power Modes (sub 4µA*)
- Variable Proximity & Touch Thresholds
- Small outline MSOP-10 package

MSOP-10



RoHS compliant

Applications

- Sanitary ware, toys, office equipment
- Flashlights, headlamps, keychain lights
- Splash- / waterproof devices
- Swipe-to-Unlock / Wake from Standby applications
- Replacement for electro-mechanical switches

Advantages

- Prevents accidental activation of conventional touch sensors
- Improved digital filtering to reduce external noise
- High immunity against aqueous substances
- Highly adjustable device with continuous data or event driven I^2C communication

Available options

T_A	MSOP10
-20°C to 85°C	IQS213A

*Current consumption dependant on selected Low Power settings.

Contents

1 Functional Overview

The **IQS213A** is a two or three channel capacitive proximity and touch sensor with variable swipe function configurations. Additional features include internal voltage regulation and reference capacitor (C_S), which enables cost efficient and minimal component designs. The device offers flexible design approaches by allowing the connection of two or three sense antennas in either surface or projected capacitance configurations.

For swipe function applications the device has a single logic output to indicate swipe actions and one complementary output for consecutive swipe/touch activities. The device can also be configured to operate with individual touch outputs, with an additional proximity output when implementing surface capacitance sense electrodes.

Full control by a master device is achieved by configuring the logic outputs in a serial data (I^2C) communication option on TO0 (SCL), TO1 (SDA) and TO2 (RDY).

Note: Programming of OTP's required to enable I^2C operation.

The device automatically tracks slow varying environmental changes via various filters, detects noise and has an Automatic Tuning Implementation (**ATI**) to tune the device for optimal sensitivity.

1.1 Applicability

All specifications, except where specifically mentioned otherwise, provided by this datasheet are applicable to the following ranges:

- Temperature: -20°C to +85°C
- Supply voltage (V_{DDHI}): 1.8V to 3.6V

2 Analogue Functionality

For self-capacitance configured sense electrodes the analogue circuitry measures the capacitance of the sense antennas attached to the C_X pins through a charge transfer process that is periodically initiated by the digital circuitry. For projected-capacitance configurations the capacitance is measured between the transmit (TX) and receive (CRX) pins. The measuring process is referred to as a conversion and consists of the discharging of C_S and C_X, the charging of C_X and then a series of charge transfers from C_X to C_S until a trip voltage is reached. The number of charge transfers required to reach the trip voltage is referred to as the Count (CS) Value.

The capacitance measurement circuitry makes use of an internal C_S and voltage reference (V_{REG}).

The analogue circuitry further provides functionality for:

- Power on reset (POR) detection.
- Brown out detection (BOD).

3 Digital Functionality

The digital processing functionality is responsible for:

- Device setup from OTP settings after POR.
- Management of BOD and WDT events.
- Initiation of conversions at the selected rate.
- Processing of CS and execution of algorithms.
- Monitoring and automatic execution of the ATI algorithm.
- Signal processing and digital filtering.
- Detection of PROX and TOUCH events.
- Managing outputs of the device.
- Managing serial communications.
- Manage programming of OTP options.

4 Hardware Configuration

4.1 IQS213A - MSOP10 Pin-Out

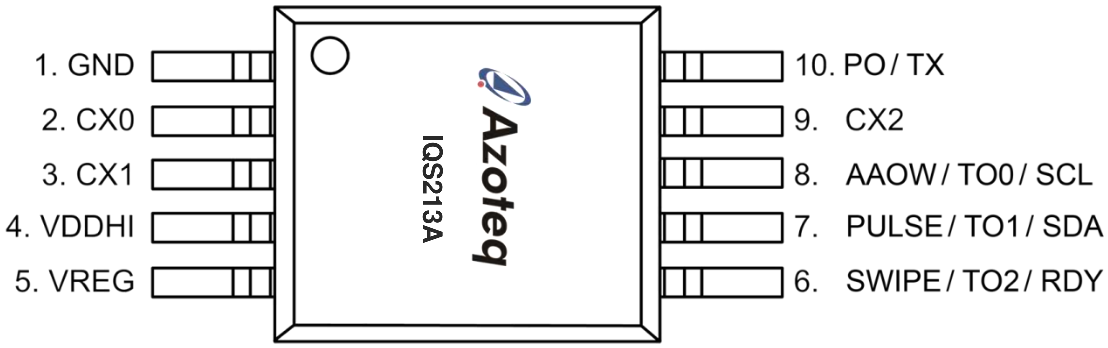


Figure 4.1 : Pin-out of IQS213A MSOP-10 package

Table 4.1 : IQS213A Pin-out

IQS213A Pin-out			
Pin	**Name**	**Type**	**Function**
1	GND	Supply Input	Ground Reference
2	CX0 (CRX0)	Analogue	Sense Electrode 0
3	CX1 (CRX1)	Analogue	Sense Electrode 1
4	VDDHI	Supply Input	Supply Voltage Input
5	VREG	Analogue Output	Internal Regulator Pin (Connect 1µF bypass capacitor)
6	SWIPE/TO2/RDY	Digital Output	Swipe Output/Touch Output/I²C: RDY Output
7	PULSE/T01/SDA	Digital Output	Pulse Output/Touch Output/I²C: SDA Output
8	AAOW/TO0/SCL	Digital I/O	Auto-Off Warning/Touch Output/I²C: SCL Input
9	CX2 (CRX2)	Analogue	Sense Electrode 2
10	PO/TX	Digital Output / Transmitter	Proximity Output/ Projected Sense Electrode

4.2 Reference Design (IQS213A, Self-Capacitance, Active-Low Output)

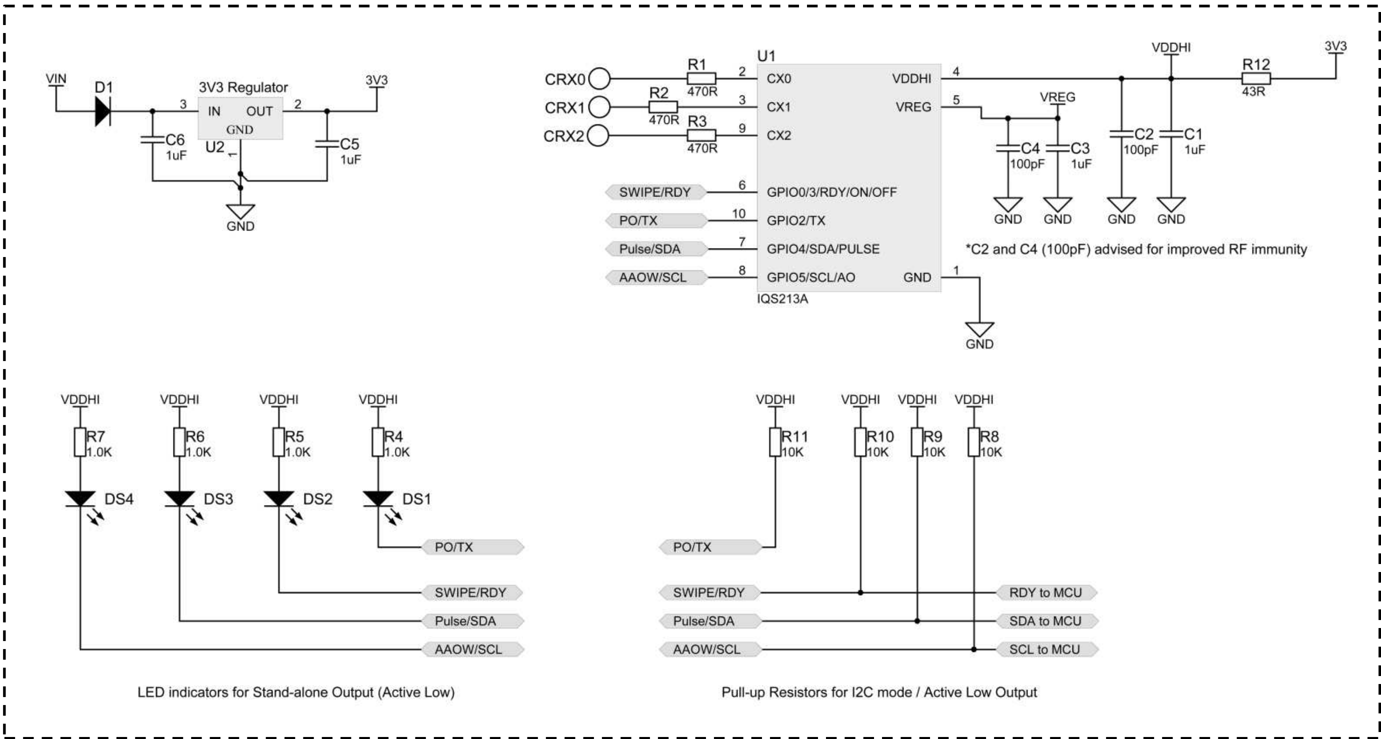


Figure 4.2 : IQS213A Reference Design (Self-Capacitance, Active-Low)

Note: For Active-Low configurations the external pull-up resistors (i.e. R8-R10) must be populated for correct functioning of the relevant Open-Drain (SW-OD) outputs. Resistor R11 should only be placed for a “Self-Capacitive” system when using the Active-Low (SW-OD) proximity output (pin10).

R12: Place a 43Ω resistor in series with the VDDHI supply line to prevent a potential ESD induced latch-up state. Maximum supply current should be limited to 80mA on the **IQS213A** VDDHI pin to prevent latch-up.

4.2.2 Power Supply and PCB Layout

Azoteq IC's provide a high level of on-chip hardware and software noise filtering and ESD protection (refer to application note “***AZD013 – ESD Overview***”). Designing PCB's with better noise immunity against EMI, FTB and ESD in mind, it is always advisable to keep the critical noise suppression components like the de-coupling capacitors and series resistors in **Figure 4.2** as close as possible to the IC. Always maintain a good ground connection and ground pour underneath the IC.

For more guidelines please refer to the relevant application notes as mentioned in **Section 4.2.3**.

4.2.3 Design Rules for Harsh EMC Environments

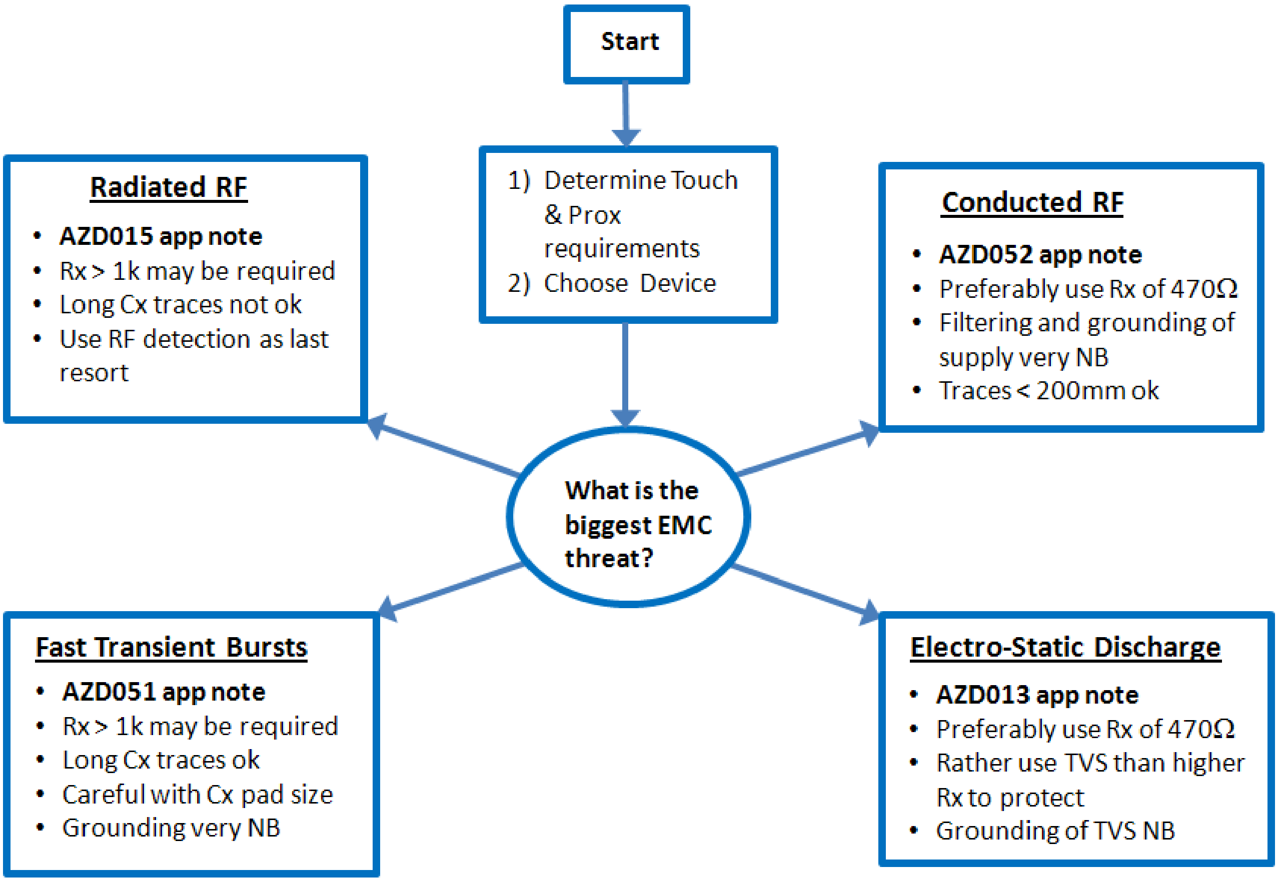


Figure 4.3 : EMC Design Rules

➢ ***Applicable application notes: AZD013, AZD015, AZD051, AZD052.***

4.2.4 High Sensitivity

Through patented design and advanced signal processing, the device is able to provide extremely high sensitivity to detect proximity. This enables designs to detect proximity at distances that cannot be equaled by most other products. When the device is used in environments where high levels of noise exist, a reduced proximity threshold is proposed to ensure reliable functioning of the sensor.

When the capacitance between the sense antenna and ground becomes too large the sensitivity of the device may be influenced. For more guidelines on layout, please refer to application note ***AZD008***, available on the Azoteq web page: www.azoteq.com.

5 User Configurable Options

The **IQS213A** provides **O**ne **T**ime **P**rogrammable (OTP) user options, which can be programmed to change the device's default start-up configuration. Blank/Un-programmed devices has a default OTP configuration = 00000000 (See **Section 5.2** for OTP options).

However, with the use of Azoteq's IQS213A GUI software, the **IQS213A** can enter streaming mode in a start-up state (*Test Mode*) where the OTP options can be configured and evaluated, before selecting OTP's for programming.

The configuration of the device can be done on packaged devices or in-circuit. In-circuit configuration may be limited by the type and/or values of external components chosen.

Please see **Section 5.3** for **IQS213A** device setup and output configuration examples.

5.1 Configuring of Devices

Azoteq offers a Configuration Tool (CT210 or later) and associated software (USBProg.exe) that can be used to program the OTP user options for prototyping purposes. More details regarding the configuration of the device with the USBProg program can be found in ***"AZD007 - USBProg Overview"*** available on the Azoteq website.

For further enquiries regarding this subject, please contact your local distributor or submit enquiries to Azoteq at: ProxSenseSupport@azoteq.com

5.2 User Selectable Configuration (OTP) Options

Table 5.1 : User Selectable Configuration (OTP) Options : Bank 0

bit7	Bank 0						bit0
THALT1	THALT0	LOGIC	FLOAT RX	PROJ	IC TYPE2	IC TYPE1	IC TYPE0

Bank0: bit7:6	**THALT1:THALT0: LTA Halt Time**	**Section 6.5**
	00 = 2.5s 01 = 20s 10 = 60s 11 = Never	
Bank0: bit5	**LOGIC: Output Logic**	**Section 6.4**
	0 = Active Low[1] 1 = Active High	
Bank0: bit4	**FLOAT RX: Float Sense Electrodes**	**Section 6.8**
	0 = No 1 = Yes	
Bank0: bit3	**PROJ: Capacitive Technology**	**Section 6.2**
	0 = Self Capacitance 1 = Projected Capacitance	
Bank0: bit2:0	**IC TYPE: Select IC type**	**Section 6.1**
	000 = 1zz 12z z2z 001 = 1zz x2x zz3 010 = 1zz z2z zz3 011 = 1zz 12z z2z z23 zz3 100 = 2CH Normal 101 = 3CH Normal 110 = 1zz 1xz x2x zx3 zz3 111 = 1zz, x2x, zz3	- 2CH SWIPE - 3CH SWIPE (Thresholds * 2) - 3CH SWIPE - 3CH SWIPE - 2 Channel Touch Sensor - 3 Channel Touch Sensor - 3CH SWIPE - 3CH SWIPE

[1] Active Low configurations are software open-drain (**SW OD**).

Note: The proximity output on the PO/TX-pin (pin 10) is multiplexed with the transmit signal (TX) for projected capacitance electrodes, and is Active High ONLY for Projected configurations.

Table 5.2 : User Selectable Configuration (OTP) Options : Bank 1

bit7	Bank 1						bit0
CH2 TTH1	CH2 TTH0	CH1, CH3 TTH1	CH1, CH3 TTH0	TTH ALT	PTH DIV	LP1	LP0

Bank1: bit7:6	**CH2 TTH1:CH2 TTH0: Channel 2 Touch Threshold**	**Section 6.8**
	TTH ALT = 0	***TTH ALT = 1***
	00 = 4	00 = 22
	01 = 8	01 = 28
	10 = 12	10 = 36
	11 = 16	11 = 48
Bank1: bit5:bit4	**CH1, CH3 TTH: Ch 1 & Ch 3 Touch Threshold**	**Section 6.8**
	TTH ALT = 0	***TTH ALT = 1***
	00 = 4	00 = 22
	01 = 8	01 = 28
	10 = 12	10 = 36
	11 = 16	11 = 48
Bank1: bit3	**TTH ALT: Alternative Touch Thresholds**	**Section 6.8**
	0 = No	
	1 = Yes	
Bank1: bit2	**PTH: Proximity Threshold Selection**	**Section 6.7**
	0 = 3 Counts	
	1 = 8 Counts	
Bank1: bit1:0	**LP1:LP0: Low Power Selection**	**Section 6.6**
	00 = NP	- Normal Power
	01 = 128ms	- Low Power Mode 1
	10 = 256ms	- Low Power Mode 2
	11 = 512ms	- Low Power Mode 3

Table 5.3 : User Selectable Configuration (OTP) Options : Bank 2

bit7	Bank 2: SWIPE IC						bit0
ACF	Pin7_OUT	CHG_FRQ	Min_State	Zero_End	Zero_State	SWIPE UI1	SWIPE UI0

Bank2: bit7	**ACF: AC Filter Selection**	**Section 6.14**
	0 = Disabled 1 = Enabled	
Bank2: bit6	**Pin7_OUT: SWIPE IC Pin 7 Output Selection**	**Section 6.13**
	0 = Touch 1 = Pulse	
Bank2: bit5	**CHG_FRQ: Charge Transfer Frequency**	**Section 8.3**
	0 = 0.5MHz / 1.0MHz (Self - / Projected Capacitance) 1 = 1.0MHz / 2.0 MHz (Self - / Projected Capacitance)	
Bank2: bit4	**Min_State: Minimum State Time**	**Section 6.12**
	0 = 1 Sample 1 = 2 Samples	
Bank2: bit3	**Zero_End: End Swipe on Zero State (zzz)**	**Section 6.11**
	0 = Disabled 1 = Enabled	
Bank2: bit 2	**Zero_State: Allow Zero States In Swipe Sequence**	**Section 6.10**
	0 = Disabled 1 = Enabled	
Bank2: bit 1:bit0	**SWIPE UI1: SWIPE UI0: Swipe UI Selection**	**Section 6.9**
	00 = Single Direction 01 = Bi-Directional 10 = Directional 11 = Dual Swipe	

Table 5.4 : User Selectable Configuration (OTP) Options : Bank 2

bit7	Bank 2: Normal Touch IC						bit0
ACF		CHG_FRQ			Toggle CH3	Toggle CH2	Toggle CH1

Bank2: bit7	**ACF: AC Filter Selection**	**Section 6.14**
	0 = Disabled 1 = Enabled	
Bank2: bit6		
Bank2: bit5	**CHG_FRQ: Charge Transfer Frequency**	**Section 8.3**
	0 = 0.5MHz / 1.0MHz (Self - / Projected Capacitance) 1 = 1.0MHz / 2.0 MHz (Self - / Projected Capacitance)	
Bank2: bit4		
Bank2: bit3		
Bank2: bit 2	**Toggle CH3: Channel 3 Touch Output = Toggle**	
	0 = Disabled 1 = Enabled	
Bank2: bit 1	**Toggle CH2: Channel 2 Touch Output = Toggle**	
	0 = Disabled 1 = Enabled	
Bank2: bit 0	**Toggle CH1: Channel 1 Touch Output = Toggle**	
	0 = Disabled 1 = Enabled	

Table 5.5 : User Selectable Configuration (OTP) Options : Bank 3

bit7	Bank 3						bit0
				AAO_CLR	AAO	ATI_Target	ATI_Base

Bank3: bit7	**System Use**
Bank3: bit6	**System Use**
Bank3: bit5	**System Use**
Bank3: bit4	**System Use**
Bank3: bit3	**AAO_CLR: Clear Auto-Off Timer On Event** **Section 6.18**
	0 = Touch Event 1 = Proximity Event
Bank3: bit 2	**AAO: Advanced Auto-Off Function Selection** **Section 6.18**
	0 = Enabled 1 = Disabled
Bank3: bit 1	**ATI_Target: ATI Target Value** **Section 6.17**
	Proximity ***Touch*** 0 = 320 160 1 = 640 320
Bank3: bit 0	**ATI_Base: ATI Base Value (All Channels)** **Section 6.16**
	0 = 75 1 = 100

Table 5.6 : User Selectable Configuration (OTP) Options : Bank 4

bit7	Bank 4						bit0
				I²C Debug			

Bank4: bit7	**System Use**
Bank4: bit6	**System Use**
Bank4: bit5	**System Use**
Bank4: bit4	**System Use**
Bank4: bit3	**I²C Debug: I²C Interface (Default = Event-Mode)** **Section 6.19**
	0 = Disabled 1 = Enabled
Bank4: bit 2	**System Use**
Bank4: bit 1	**System Use**
Bank4: bit 0	**System Use**

5.3 IQS213A Setup Examples

5.3.1 Example 1: 3-Channel Self Capacitive, Active Low Logic Output, SwipeSwitch with Auxiliary Touch Output.

Example 1 (see **Figure 5.1**) illustrates the user interface (UI) and device outputs for a **3-Channel Self Capacitive SwipeSwitch** (output on pin 6), in an active low configuration with the Directional UI and Auxiliary **Touch** Output on pin 7.

5.3.1.1 Selected User Configuration Options (Example 1):

bit7	Bank 0						bit0
THALT1	THALT0	LOGIC	FLOAT RX	PROJ	IC TYPE2	IC TYPE1	IC TYPE0
0	0	0	N/A	0	*	*	*

*** The IC TYPE can be any 3-Channel SwipeSwitch™ option, e.g. 001,110 or 111.

THALT1:0 = 00 – 2.5s Halt time selected for this example.

bit7	Bank 1						bit0
CH2 TTH1	CH2 TTH0	CH1, CH3 TTH1	CH1, CH3 TTH0	TTH ALT	PTH DIV	LP1	LP0
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

bit7	Bank 2: SWIPE IC						bit0
ACF	Pin7_OUT	CHG_FRQ	Min_State	Zero_End	Zero_State	SWIPE UI1	SWIPE UI0
N/A	0	N/A	N/A	N/A	N/A	1	0

bit7	Bank 4						bit0
				I²C Debug			
				0			

5.3.1.2 Device outputs (Directional SwipeSwitch™ UI)

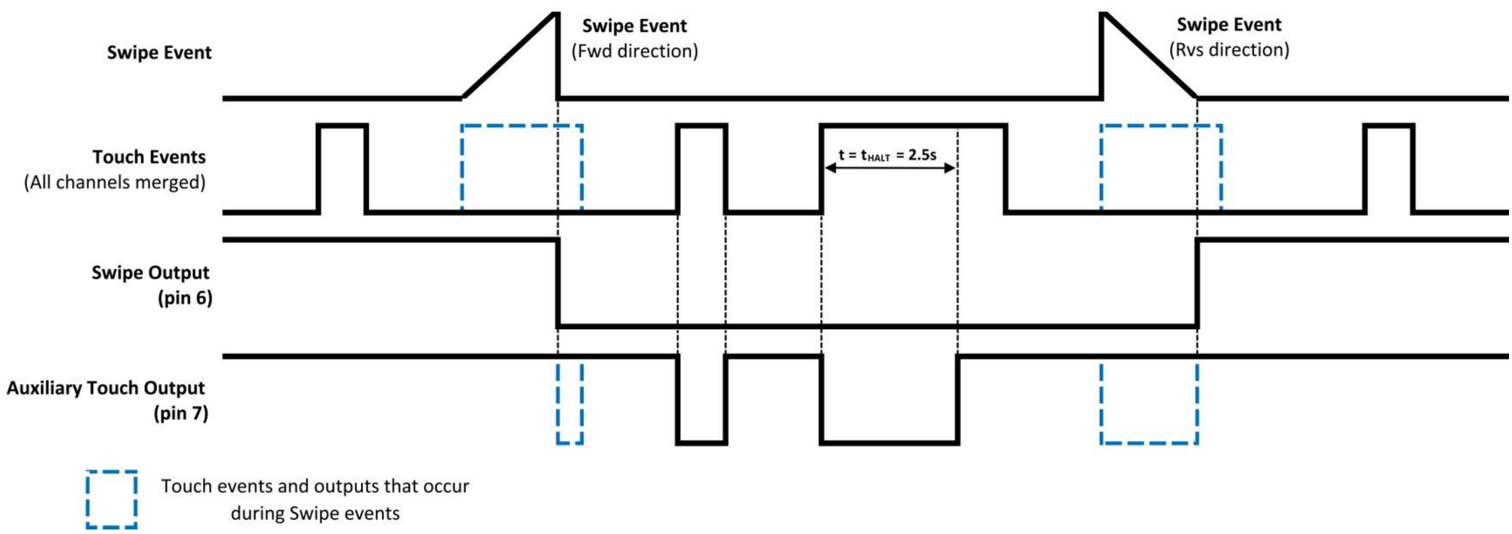


Figure 5.1 : IQS213A setup example 1

5.3.2 Example 2: 3-Channel Projected Capacitive, Active High Logic Output, SwipeSwitch with Auxiliary Swipe Pulse Output.

Example 2 (see **Figure 5.2**) illustrates the user interface (UI) and device outputs for a **3-Channel Projected Capacitive SwipeSwitch** (output on pin 6), in an active high configuration with the Bi-Directional UI and Auxiliary **Swipe Pulse** Output on pin 7.

5.3.2.1 Selected User Configuration Options (Example 2):

bit7	Bank 0						bit0
THALT1	THALT0	LOGIC	FLOAT RX	PROJ	IC TYPE2	IC TYPE1	IC TYPE0
N/A	N/A	1	N/A	1	*	*	*

*** The IC TYPE can be any 3-Channel SwipeSwitch option, e.g. 001,110 or 111.

bit7	Bank 1						bit0
CH2 TTH1	CH2 TTH0	CH1, CH3 TTH1	CH1, CH3 TTH0	TTH ALT	PTH DIV	LP1	LP0
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

bit7	Bank 2: SWIPE IC						bit0
ACF	Pin7_OUT	CHG_FRQ	Min_State	Zero_End	Zero_State	SWIPE UI1	SWIPE UI0
N/A	1	N/A	N/A	N/A	N/A	0	1

Pin7_OUT = 1 : The output on pin 7 will be a pulse signal *(within a 2-second window), of which the pulse length depends on the direction of the swipe event. See Section 6.13. *The 2-second window is reset after each swipe event.

bit7	Bank 4						bit0
				I²C Debug			
				0			

5.3.2.2 Device outputs (Bi-Directional SwipeSwitch UI)

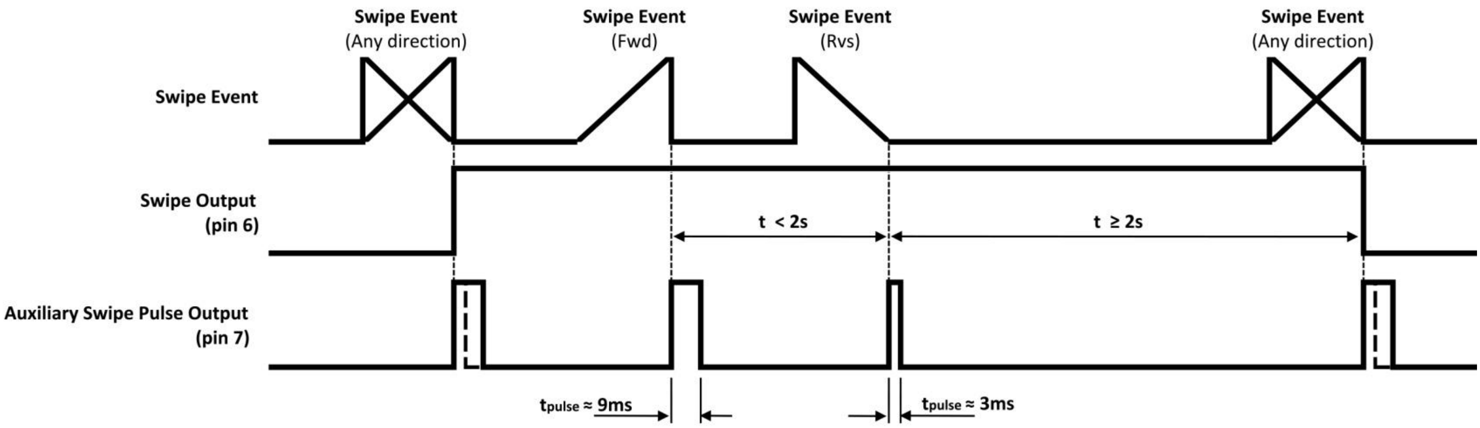


Figure 5.2 : IQS213A Setup example 2

5.3.3 Example 3: Normal Mode Operation

Example 3 illustrates the user interface (UI) and device outputs for a **2- or 3-Channel Normal Mode (TOUCH) Device**, with optional toggle state outputs. Note that the lower three bits of Bank2 are reserved for Toggle options, when the IC TYPE is selected in a Normal Mode configuration. The Normal Mode (i.e Touch) device can be either Self- or Projected Capacitive with either Active High or Active Low (Logic) outputs.

5.3.3.1 Example 3.1: 2-Channel Normal Mode – No Toggle Active, Active Low Logic

bit7	Bank 0						bit0
THALT1	THALT0	LOGIC	FLOAT RX	PROJ	IC TYPE2	IC TYPE1	IC TYPE0
N/A	N/A	0	N/A	N/A	1	0	0

bit7	Bank 2: Normal Touch IC						bit0
ACF		CHG_FRQ			Toggle CH3	Toggle CH2	Toggle CH1
N/A		N/A			0	0	0

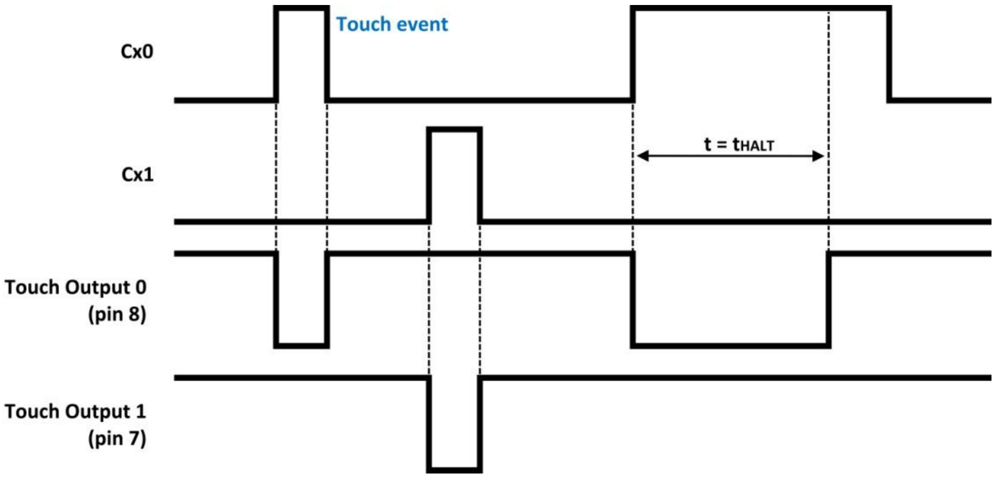


Figure 5.3 : IQS213A Setup example 3.1

5.3.3.2 Example 3.2: 3-Channel Normal Mode – All Toggles Active, Active High Logic

bit7	Bank 0						bit0
THALT1	THALT0	LOGIC	FLOAT RX	PROJ	IC TYPE2	IC TYPE1	IC TYPE0
N/A	N/A	1	N/A	N/A	1	0	1

bit7	Bank 2: Normal Touch IC						bit0
ACF		CHG_FRQ			Toggle CH3	Toggle CH2	Toggle CH1
N/A		N/A			1	1	1

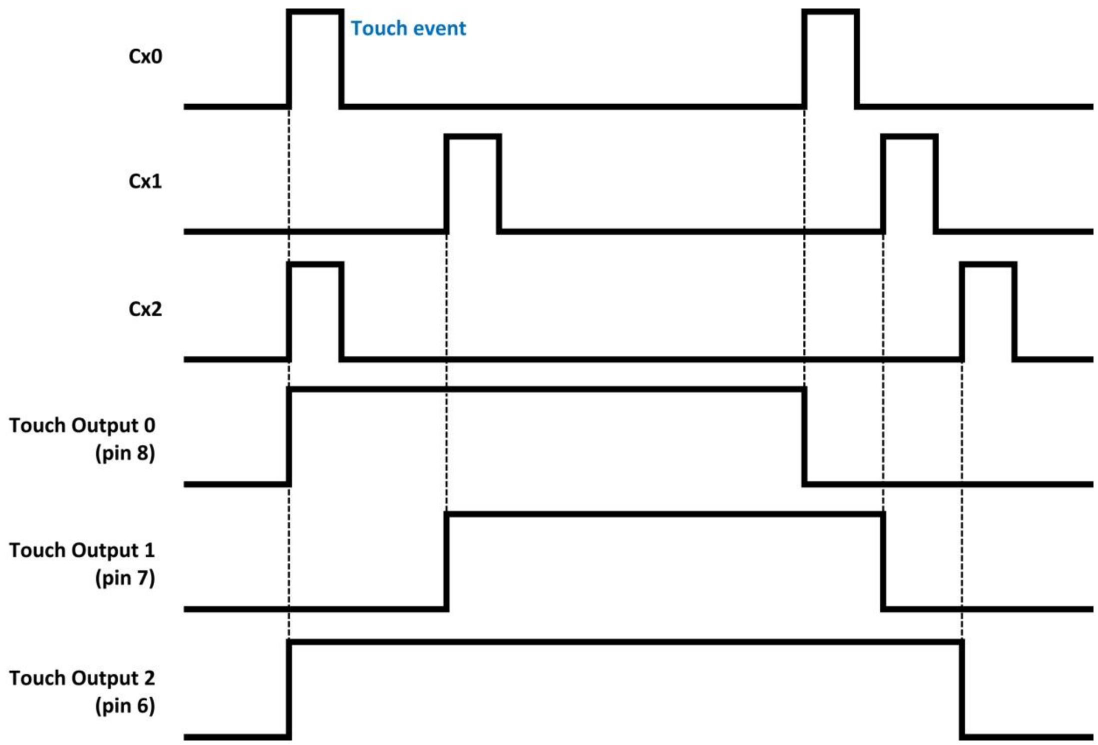


Figure 5.4 : IQS213A Setup example 3.2

6 Description of User Selectable Options

This section briefly describes the individual user programmable options of the **IQS213A**, with additional information and detailed descriptions being provided in **Section 8**.

Thresholds and other settings can also be evaluated in Test Mode streaming without programming the OTP options. For the appropriate software, please visit: www.azoteq.com

6.1 IQS213A IC Type

The **IQS213A** has six selectable Swipe-Switch™ setup configurations, allowing the user maximum freedom in the design of the intended application. The device type configuration specifies the required user input, which is identified by a sequence of a combination of input states, where a *[number]* (e.g. 1, 2 or 3) indicates a touch condition/state on that specific channel, a *[z-character]* indicates a zero condition/state and a *[x-character]* indicates a "don't care" condition/state (i.e. a number or zero condition is acceptable). The input states related to sequences accepting x-character conditions are also referred to as relaxed states.

- **2CH SWIPE - 1zz 12z z2z** : 2-Channel swipe switch operation.
- **3CH SWIPE – 1zz x2x zz3 (TH*2)** : 3-Channel swipe switch operation.
- **3CH SWIPE - 1zz z2z zz3** : 3-Channel swipe switch operation.
- **3CH SWIPE - 1zz 12z z2z z23 zz3** : 3-Channel swipe switch operation.
- **3CH SWIPE - 1zz 1xz x2x zx3 zz3** : 3-Channel swipe with relaxed states.
- **3CH SWIPE - 1zz x2x zz3** : 3-Channel swipe with relaxed states.

The **IQS213A** also has 2 selectable normal setup configurations, which allows the user to implement standard touch and proximity sensing features.

- **2CH Normal Mode** : 2-Channel Normal Touch operation.
- **3CH Normal Mode** : 3-Channel Normal Touch operation.

With the device setup in either 2-channel or 3-channel Normal Mode, touch events corresponding to the different sense electrodes will be output on TO0 (pin 8), TO1 (pin 7) and TO2 (pin 6), with a proximity output available on PO (pin 10).

During Normal Mode operation, setting the different "Toggle_CH*x*" bits in Bank 2, will enable the touch output signals to toggle.

6.2 Self- / Projected Capacitance

Enabling the projected capacitance option, will cause the measurement of the sense electrode capacitance between the transmit (TX) and receive (CRX) pins.

The proximity output on the PO/TX-pin (pin 10) is multiplexed with the transmit signal (TX) for projected capacitance electrodes, and is Active High ONLY for such configurations.

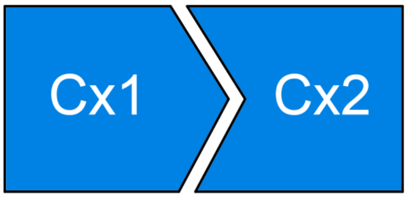
The implementation of a projected capacitance sense electrode will result in a higher charge frequency (i.e. f_{Cm} = 1MHz) compared to that of a self capacitance configuration (i.e. f_{Cs}= 500kHz). Setting bit5 in Bank2 will double the charge frequency for both projected- and self capacitance configurations (i.e. f_{Cm} / f_{Cs}= 2MHz / 1MHz).

A higher charge frequency selection is preferred for increased immunity against aqueous substances when used in most projected capacitance configurations.

6.2.1 Capacitive Sense Electrode Design Samples

6.2.1.1 Self Capacitance Electrodes

2-Channel Self Capacitance Electrode

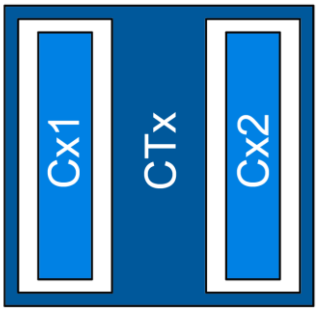


3-Channel Self Capacitance Electrode

Figure 6.1 : Self Capacitance Swipe Switch Sample Electrodes.

6.2.1.2 Projected Capacitance Electrodes

2-Channel Projected Capacitance Electrode



3-Channel Projected Capacitance Electrode

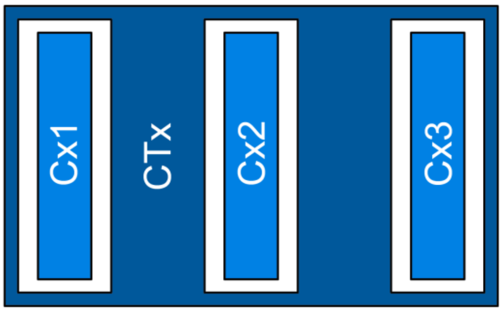


Figure 6.2 : Projected Capacitance Swipe Switch Sample Electrodes.

6.3 Float Rx

During the charge transfer process (see **Figure 8.1**) the channels that are not being processed during the current cycle, is effectively grounded to decrease the effects of noise-coupling between the sense electrodes. Selecting the "Float RX" option (Bank0 bit4), will thus result in the non-current channels to float (i.e. not grounded) during the charge cycle of the current channel.

6.4 Output Logic Select

The **IQS213A** can be set to sink or source current in stand-alone mode (I^2C Debug = Disabled), by setting the logic output Active High (Push-Pull) or Active Low (SW OD).

For Active Low operation, the device output pins are set in a software open-drain (SW OD) configuration, which requires the use of external pull-up resistors on the output pins.

The proximity output on the PO/TX-pin (pin 10) is multiplexed with the transmit signal (TX) for projected capacitance electrodes, and is Active High ONLY for Projected configurations. Thus for self capacitance configurations, the proximity output on PO (pin10) depends on the selected output logic (Bank0 bit5).

6.5 Halt Time

The Halt Timer is started when a proximity or touch event occurs and is restarted when that event is removed or reoccurs. When a proximity condition occurs on any of the channels, the LTA (**L**ong-**T**erm **A**verage) value for that channel will be "halted", thus its value will be kept fixed, until the proximity event is cleared, or the halt timer reaches the halt time. The halt timer will count to the selected halt time (t_{HALT}), which can be configured in the user selectable options (i.e. Bank0 bit7:6), and if the timer expires, all outputs will be cleared.

It is possible that the CS (Count) value could be outside the ATI band (ATI Target +-12.5%) when the timer expires, which will cause the device to perform a re-ATI event.

The designer needs to select a halt timer value (t_{HALT}) to best accommodate the required application:

- **2.5 seconds** : Halt LTA for 2.5 seconds after the last proximity or touch event.
- **20 seconds** : Halt LTA for 20 seconds after the last proximity or touch event.
- **60 seconds** : Halt LTA for 60 seconds after the last proximity or touch event.
- **Never** : Never halt LTA

* *With the 'Never' option, the detection of a proximity or touch event will not halt the LTA and the LTA will adjust towards the CS value until the CS value is reached. The touch and proximity output of a channel will thus be cleared automatically when the difference between the LTA and CS is less than the specified threshold value.*

6.6 Low Power Modes

The **IQS213A** IC has three low power modes specifically designed to reduce current consumption for battery applications.

The power modes are implemented around the occurrence of a charge cycle every t_{SAMPLE} seconds (refer to **Table 6.1**). Lower sampling frequencies typically yield significant lower power consumption (but also decreases the response time).

During normal operation charge cycles are initiated approximately every 2.6ms in the stand-alone setup and 3.9ms in the I²C debug setup. This is referred to as Normal Power Mode (NP). The **IQS213A** by default charges in Normal Power Mode.

While in any low power mode, only Channel 0 is active and the device will zoom to NP whenever the CS value indicates a possible proximity or touch event on CH0 (refer to **Figure 6.3**). This improves the response time. The device will remain in NP for t_{ZOOM} seconds and then return to the selected low power mode. The Zoom function allows reliable detection of events with the current samples being produced at the NP rate. Please see **Section 8.4** or refer to ***"Application Note AZD079 – IQS213 Touch response rate"*** for more information.

Table 6.1 : Low Power Mode Timing (t_{LP})

Power Mode	t_{SAMPLE} (Stand-alone)	t_{SAMPLE} (I^2C)
NP (Default)	2.6 ms	3.9ms
LP1	128 ms	128ms
LP2	256 ms	256ms
LP3	512 ms	512ms

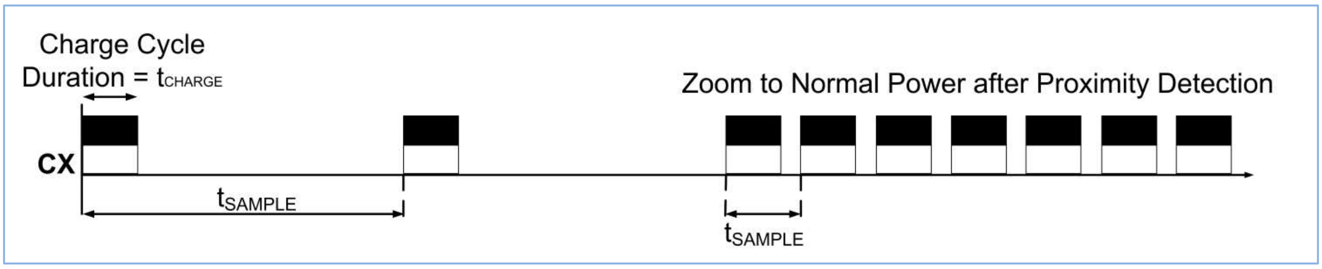


Figure 6.3 : LP Modes – Charge Cycles

6.7 Proximity Threshold

The **IQS213A** has 2 proximity threshold (P_{TH}) settings. The proximity threshold is selected by the designer to obtain the desired sensitivity and noise immunity. The proximity event is triggered based on the selected proximity threshold, which is either 3 or 8 counts.

The proximity threshold is expressed in terms of counts, the same as the CS value.

For proximity events, the difference between the LTA and CS (in counts) of the proximity channel should be greater than P_{TH} for at least 4 consecutive samples, unless the CS delta is greater than the touch threshold of any active channel. (See **Section 8.8**)

6.8 Touch Thresholds

The **IQS213A** has 8 touch threshold settings. The touch threshold is selected by the designer to obtain the desired touch sensitivity.

The touch event is triggered based on the selected touch threshold, which is expressed as a fraction of the LTA, given by:

$T_{TH} = x/255 \times LTA$. (See **Section 8.8**)

For a touch event, the difference between LTA and CS (counts) of the touch channel should be greater than the selected touch threshold for at least 2 consecutive samples.

On the **IQS213A** device, the touch threshold settings are grouped for channels 1 and 3 (CH1,3 T_{TH}) and is separate for channel 2 (CH2 T_{TH}).

The **IQS213A** device is by default setup without the alternative threshold settings. The alternative threshold values can be selected by setting the TTH_ALT bit (i.e. bit3 in Bank1).

If for specific applications the designer requires larger touch threshold values than the available selections, they may select the “3CH SWIPE – 1zz x2x zz3 (TH*2)” IC TYPE in Bank0 of the user configurable options.

This selection is for a three channel sense electrode configuration only and will automatically multiply the threshold selections by two.

6.9 IQS213A SWIPE UI

The **IQS213A** has 4 selectable swipe switch user interface (UI) configurations. The swipe UI specifies the required event(s) to activate the outputs of the device:

- **Single Direction:**

  The device only acknowledges swipe events in the direction of **CH1>CH2** for a 2-channel and **CH1>CH2>CH3** for a 3-channel device setup.

- **Bi-Directional:**

  The device acknowledges swipe events in both the forward (**CH1>CH2>...**) and reverse (**...>CH2>CH1**) directions.

- **Directional:**

  A swipe event in the forward (**CH1>CH2>...**) direction will enable the swipe output (ON) and a swipe in the reverse (**...>CH2>CH1**) direction will disable the output (OFF).

- **Dual Swipe:**

  This UI requires a swipe event in one direction, followed by a swipe event in the opposite direction within 1 second, to enable the swipe output (ON). Thereafter, a single swipe in any direction will subsequently disable the swipe output again (OFF).

6.10 Zero States Allowed

Setting the **Zero_State** bit in Bank2, will allow the occurrence of zero or "no touch" conditions between the different state combinations in each sequence of the selected IC type (refer to **Section 6.1** for IC types).

This grants the designer a certain degree of freedom in the selected device sensitivity and implemented sense electrode.

If for example the IC type is selected to be "**3CH SWIPE - 1zz z2z zz3**", then the sequence '**1zz zzz z2z zzz zz3**' of state combinations will also be acknowledged as a valid swipe event.

6.11 End on Zero State

Setting the **Zero_End** bit in Bank2, will append an additional zero or "no touch" state to the required sequence of state combinations.

If for example the IC type is selected to be "**3CH SWIPE - 1zz z2z zz3**", then the sequence '**1zz z2z zz3 zzz**' of state combinations will be acknowledged as a valid swipe event ONLY.

6.12 State Times

The minimum, maximum and overall swipe state times controls the effective period during which a successful swipe event can be recognized. The state times are defined in swipe state samples, where each sample period t_{STATE} is equal to 4 charge transfer periods. For stand-alone device operation this results in a state sample time of approximately t_{STATE} = 10.4ms.

The state time values can also be set up or changed in I^2C debug mode.

6.12.1 Minimum State Time

The minimum state time (t_{MIN}) defines the minimum period (in multiples of t_{STATE}) for which each combination of states (e.g. 1zz) must be present during processing of the current sequence of the state combination. Selecting shorter minimum state times will effectively allow faster swipe events.

6.12.2 Maximum State Time

The maximum state time defines the maximum period for which each combination of states (e.g. 1zz) may be present during processing of the current sequence of the state combination.

This value is fixed at $t_{MAX} = 45*t_{STATE}$ by default, but is accessible in I^2C debug mode. Selecting longer maximum state times will effectively allow slower swipe events.

6.12.3 Overall State Time

The overall state time is the total allowable time for performing a swipe event and is by default set to 1 second. This value can also be changed in I^2C debug mode in steps of 250ms.

6.13 Touch/Swipe (Pin7) Output

The **IQS213A** has one complementary output on pin 7 of the IC. This pin can be configured to output either touch events or pulses upon swipe events, after the swipe output (pin 6) has been enabled.

By default the **IQS213A** will output a logic signal for touch events on any of the three sense electrodes. If the **Pin7_Out** bit in Bank2 is set, the device will output a short pulse for every consecutive swipe event within 2 seconds after the first swipe event.

The generated pulses have different pulse widths (t_{PULSE}), depending on the direction of the swipe event:

- **Long Pulse:** A long pulse ($t_{PULSE} \approx$ 9ms) will be output for swipes in the forward (**CH1>CH2...**) direction.
- **Short Pulse:** A short pulse ($t_{PULSE} \approx$ 3ms) will be output for swipes in the reverse (**...>CH2>CH1**) direction.

6.14 AC Filter

The AC filter can be implemented to provide better stability of the proximity channel's count (CS) measurements in electrically noisy environments by setting the **ACF** bit in Bank2.

The AC filter also enforces a longer minimum sample time for detecting proximity events, which may result in a slower response rate when the device enters low power modes.

6.15 ATI Method

In the stand-alone configuration the **IQS213A** is automatically set up in Full ATI to set up the device for optimal sensitivity.

In the I^2C debug configuration, the **IQS213A** can be set up to start in two ways, Full ATI and Partial ATI. In Full ATI mode, the device automatically selects the multipliers through the ATI algorithm to setup the **IQS213A** as close as possible to its default sensitivity for the environment where it was placed. The designer can, however, select Partial ATI, and set the multipliers to a pre configured value. This will cause the **IQS213A** to only calculate the compensation (not the compensation and multipliers as in Full ATI), which allows the freedom to make the **IQS213A** more or less sensitive for its intended environment of use. (Please refer to **Section 8.9.**)

6.16 Base Value

The **IQS213A** has the option to change the base value of all channels during the ATI algorithm. Depending on the application, this provides the user with another option to select the sensitivity of the **IQS213A** without changes in the hardware (CX sizes and routing, etc). By setting the **ATI_Base** bit in Bank3, the base value can be set to be 75 or 100. A lower base value will typically result in a higher sensitivity of the device. (Refer to **Section 8.9**)

6.17 ATI Target Value

The default target counts of the **IQS213A** are 320 for the proximity channel, and 160 for the touch channels.

However, for some applications, a more sensitive device and higher target is required.

Therefore, the **ATI_Target** bit in Bank3 can be set, changing the targets to 640 for the proximity channel, and 320 for the touch channels. (See **Section 8.9**)

6.18 Auto-Off / Advanced Auto-Off Warning

To prevent battery drainage in the unlikely event of a false activation of the output load, the **IQS213A** is equipped with an Auto-Off functionality. The Auto-Off (AAO) feature can be disabled by setting the **AAO** bit in Bank3.

6.18.1 Advanced Auto-Off Warning (AAOW)

In stand-alone operation the Advanced Auto-Off Warning (AAOW) timer is set for 10 minutes. After the first warning, a second warning will be given after 30s. Another 30s after the second warning, the device will switch off automatically (i.e. disable all outputs).

In I^2C operation the Auto-Off (AAO) and Advanced Auto-Off Warning (AAOW) timers can be set to any value in multiples of 30s.

6.18.2 AAOW Clear / Reset

The AAO timer is by default cleared (reset) on a touch event on any channel. Setting the **AAO_CLR** bit in Bank3, the AAO timer will be reset upon a proximity event.

6.19 I^2C Debug

A streaming option is available that allows for serial data communication on the **IQS213A**. Data streaming is done via an I^2C compatible 3-wire interface, which consist of a data (**SDA**), clock (**SCL**) and ready (**RDY**) line (for **IQS213A** pin-out refer to **Figure 4.1**).

The **IQS213A** can only function as a slave device on the bus, and will only acknowledge on address **0x44H**.

The RDY line is to be used by the host controller as an indication of when to start communication to the device. The RDY line will be active low when it is ready for communication, and it will go high when it is doing conversions. The **IQS213A** will not acknowledge (ACK) on its address while the RDY line is high (i.e. while the **IQS213A** is doing conversions).

7 Additional Features

7.1 Noise Detection

The **IQS213A** has advanced integrated immunity to RF noise sources such as GSM cellular telephones, DECT, Bluetooth and WIFI devices. Design guidelines should however be followed to ensure the best noise immunity. (Please see **Section 8.10**)

7.1.1 Notes for layout:

- A ground plane should be placed under the IC, except under the CX lines.
- Place the sensor IC as close as possible to the sense electrodes.
- All the tracks on the PCB must be kept as short as possible.
- The capacitor between VDDHI and GND as well as between VREG and GND must be placed as close as possible to the IC.
- A 100 pF capacitor can be placed in parallel with the 1uF capacitor between VDDHI and GND. Another 100 pF capacitor can be placed in parallel with the 1uF capacitor between VREG and GND.
- When the device is too sensitive for a specific application a parasitic capacitor (max 5pF) can be added between the CX line and ground.
- Proper sense antenna and button design principles must be followed.
- Unintentional coupling of sense antenna to ground and other circuitry must be limited by increasing the distance to these sources.

- In some instances a ground plane some distance from the device and sense antenna may provide significant shielding from undesirable interference.
  - ∗ However, if after proper layout, interference from an RF noise source persists, see application note ***AZD015***.