IQS7222x User Guide

User guide for IQS7222x series. Description of self and mutual capacitive and self and mutual inductive sensing

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1 General Setup Guidelines

1.1 Cycle Setup

Each Cycle applies to two channels, one channel on Prox engine A and a second on Prox Engine B. The channels related to each cycle for the IQS7222B, IQS7222A and IQS7222C is described in section 1.4 and section 1.5 respectively.

Settings related to cycle setup is shown in table 1.1 below.

Table 1.1: Cycle Settings

Setting	Description	Options
PXS Mode	Cycle mode	Self-capacitive Mutual Capacitive Inductive Hall switch (IQS7222A only) Hall control (IQS7222A only)
Conversion Frequency Fraction	Frequency fraction relates to charge transfer frequency	Recommended = 127
Conversion Frequency Period	Determines the charge transfer frequency f_{clk} = 14MHz/ 18MHz - Refer to relevant datasheet Dead time enabled: $f_{xfer} = \frac{f_clk}{2*period+3}$ Dead time disabled: $f_{xfer} = \frac{f_clk}{2*period+2}$	0 - 255
Tx Selection	Select to enable desired Tx	CTx0 to CTx8
Ground Inactive Rx's	Ground or float unused Rx's	Ground or float
Dead Time Enable	Enable dead time - period between the time the external load is changed and just before the input to the prox engine is opened to let the charge flow into the CS cap	Enable or disable
F_{OSC} Tx Frequency	Enable F_{OSC} as charge transfer frequency (enable for inductive sensing)	Enable or disable
V_{bias} enable	Enable Vbias (constant voltage drive onto CTx8) for resonant inductive sensing	Enable or disable
Maximum Counts	Maximum count value	1023 2047 4095 16384
Auto Mode	Number of conversions before each interrupt is generated	4 8 16 32
ATI parameters Preload	Preloads from which the device will determine ATI parameters	
Current reference trim	Determine current source output value	0 - 15
Current reference level		0 - 15
Current reference output	Enable Current source output	None Enable to self-inductance pads Enable to Hall coils
Current reference enable	Enable source current	Enable or disable

1.2 Channel Setup

The channels related to each cycle for the IQS7222B, IQS7222A and IQS7222C is described in section 1.4 and section 1.5 respectively.

Settings related to channel setup is shown in table 1.2 below.

Table 1.2: Channel Settings

Setting	Description	Options
Rx Selection	Select to enable desired Rx	CRx0 to CRx7
Prox Threshold	Value at which a prox event will be triggered	8 bit value
Touch Threshold	Value at which a touch event will be triggered $\text{Threshold} = \frac{\text{8-bit value}*LTA}{256}$	8 bit value
Touch Hysteresis	Hysteresis value on touch release $\text{Release threshold} = \frac{\text{LTA * Threshold bit value}}{2^8} - \frac{\text{Threshold bit value * Hysteresis bit value *LTA}}{2^{16}}$	8 bit value
Proximity event timeouts	Channel state will timeout (channel counts will reseed to the LTA value) after chosen time value	0 - 127.5 seconds 0 = never timeout (recommended for use with follower and reference channels and required for ULP entry channels retaining an active state in ULP)
Touch event timeouts	Channel state will timeout (channel counts will reseed to the LTA value) after chosen time value	0 - 127.5 seconds 0 = never timeout (recommended for use with follower and reference channels and required for ULP entry channels retaining an active state in ULP)
Enter debounce value	Debounce factor before entering touch/prox state	4 bit value
Exit debounce value	Debounce factor before exiting touch/prox state	4 bit value
ATI Mode	Auto tuning implementation mode	› Full ATI › ATI from compensation only › ATI from compensation divider › ATI from fine fractional divider › ATI from coarse fractional divider › ATI disabled
ATI Base	Base value for ATI, influences sensitivity. Lower base value will increase sensitivity	5 bit value * 16
ATI Target	Target value for ATI, influences sensitivity. Lower target value will decrease sensitivity	8 bit value * 8
ATI Parameters	Parameters that can be adjusted to reach the specified ATI target and base › Compensation › Compensation divider › Coarse fractional multiplier › Coarse fractional divider	Refer to relevant IQS7222x datasheet

	> Fine fractional divider	
Invert direction	Bit to set direction of sensing	Disable: Activation when Counts < LTA - threshold Enable: Activation when Counts > LTA + threshold
Bi-directional sensing	Enables event triggering in both directions (counts > LTA & counts < LTA)	Disable: Trigger only allowed in active direction Enable: Trigger allowed in both directions
Global Halt	Bit to globally halt LTA adjustment on all global halt enabled channels	Disable: LTA adjusts Enable: LTA is halted
Vref 0.5V Enable	Halves internal sampling capacitor size	Disable: C_S capacitor = value specified in Cs Size (40pF/80pF) Enable: C_S capacitor = half of the value specified in Cs Size (40pF/80pF)
Projected Bias select	Selection of bias current for mutual capacitive mode	2μA 5μA 7μA 10μA
ATI Band	ATI will be executed if LTA moves outside this band	1/x * ATI Target
Cs Size	Internal calibration capacitor size - used if the load is very small and the base value can not be set by using the maximum multiplier	40pF 80pF
Channel Enable	Enable/disable channel	Channel disabled Channel enabled

1.3 Rx Prox Engine Relationship

The Rx options are confined to specific Prox engines as shown in table 1.3. For channels applicable to each Prox engine for IQS7222B, IQS7222A and IQS7222C, please refer to table 1.4 and table 1.5 respectively.

Table 1.3: Rx Prox Engine Relationship

CRx	Prox Engine A	Prox Engine B
CRx0	✓	-
CRx1	✓	-
CRx2	✓	-
CRx3	✓	-
CRx4	-	✓
CRx5	-	✓
CRx6	-	✓
CRx7	-	✓

1.4 IQS7222B Cycle and Channel Relationship

The IQS7222B has 10 cycles and 20 channels. The relationship between the cycles and channels are shown in table 1.4 below.

Table 1.4: IQS7222B Cycle and Channel Relationship

Cycle	Channel on Prox Engine A	Channel on Prox Engine B
Cycle 0	Channel 0	Channel 10
Cycle 1	Channel 1	Channel 11
Cycle 2	Channel 2	Channel 12
Cycle 3	Channel 3	Channel 13
Cycle 4	Channel 4	Channel 14
Cycle 5	Channel 5	Channel 15
Cycle 6	Channel 6	Channel 16
Cycle 7	Channel 7	Channel 17
Cycle 8	Channel 8	Channel 18
Cycle 9	Channel 9	Channel 19

1.5 IQS7222A & IQS7222C Cycle and Channel Relationship

The IQS7222A and IQS7222C have 5 cycles and 10 channels. The relationship between the cycles and channels are shown in table 1.5 below. The IQS7222A has 2 extra channel which are used for Hall effect as described in section 8.

Table 1.5: IQS7222A & IQS7222C Cycle and Channel Relationship

Cycle	Channel on Prox Engine A	Channel on Prox Engine B
Cycle 0	Channel 0	Channel 5
Cycle 1	Channel 1	Channel 6
Cycle 2	Channel 2	Channel 7
Cycle 3	Channel 3	Channel 8
Cycle 4	Channel 4	Channel 9

2 Self-capacitive Sensing

2.1 Principle of Self-capacitive Sensing

Surface or Self-capacitance makes use of the parallel plate capacitor theory: C = (ϵ_r ϵ_o A)/d. The capacitance is measured between the electrode and earth.

- As a finger approaches the electrode the distance (d) between electrode and earth decreases, effectively increasing the capacitance (C).
- Q = CV. With C increasing, it will yield the charge (Q) per transfer will also increase.
- This will decrease the amount of transfers required to charge the electrode.

2.2 Electrode Layout for Self-capacitive Sensing

Please refer to application note AZD008

2.3 Configuring IQS7222x Device for Self-capacitive Sensing

Table 2.1: Cycle Settings for Self-capacitive Sensing

Setting	Description	Recommended Value
PXS Mode	Cycle mode	Self-capacitive
Conversion Frequency Fraction	Frequency fraction relates to charge transfer frequency	127
Conversion Frequency Period	Determines the charge transfer frequency	Decimal value that results in f_{xfer} = 500kHz (refer to relevant datasheet)
Tx Selection	Select to enable desired Tx	Select Tx corresponding to Rx used on both channels on current cycle. E.g if CRx0 is used for channel 0 and Rx4 is used for channel 5, select CTx0 and CTx4 for cycle 0
Ground Inactive Rx's	Ground or float unused Rx's	Ground
Dead Time Enable	Enable dead time - period between the time the external load is changed and just before the input to the prox engine is opened to let the charge flow into the CS cap	Enable
F_{OSC} Tx Frequency	Enable F_{OSC} as charge transfer frequency (enable for inductive sensing)	Disable
V_{bias} enable	Enable Vbias (constant voltage drive onto CTx8) for resonant inductive sensing	Disable
Maximum Counts	Maximum count value	Application specific
Auto Mode	Number of conversions before each interrupt is generated	Application specific
ATI parameters Preload	Preloads from which the device will determine ATI parameters	Application specific
Current reference trim	Determine current source output value	0
Current reference level		0
Current reference output	Enable Current source output	None
Current reference enable	Enable source current	Disable

Table 2.2: Channel Settings

Setting	Description	Recommended Value
Rx Selection	Select to enable desired Rx	CRx0 to CRx7
Prox Threshold	Value at which a prox event will be triggered	Application specific
Touch Threshold	Value at which a touch event will be triggered $\text{Threshold} = \frac{\text{8-bit value} * LTA}{256}$	Application specific
Touch Hysteresis	Hysteresis value on touch release $\text{Release Threshold} = \frac{\text{LTA * Threshold bit value}}{2^8} - \frac{\text{Threshold bit value * Hysteresis bit value * LTA}}{2^{16}}$	Application specific
Proximity event timeouts	Channel state will timeout (channel counts will reseed to the LTA value) after chosen time value	Application specific
Touch event timeouts	Channel state will timeout (channel counts will reseed to the LTA value) after chosen time value	Application specific
Enter debounce value	Debounce factor before entering touch/prox state	Application specific
Exit debounce value	Debounce factor before exiting touch/prox state	Application specific
ATI Mode	Auto tuning implementation mode	› Full ATI › ATI from compensation only › ATI from compensation divider › ATI from fine fractional divider › ATI from coarse fractional divider › ATI disabled
ATI Base	Base value for ATI, influences sensitivity. Lower base value will increase sensitivity	Application specific
ATI Target	Target value for ATI, influences sensitivity. Lower target value will decrease sensitivity	Application specific
ATI Parameters	Parameters that can be adjusted to reach the specified ATI target and base › Compensation › Compensation divider › Coarse fractional multiplier › Coarse fractional divider › Fine fractional divider	Refer to relevant IQS7222x datasheet
Invert direction	Bit to set direction of sensing	Disable (activation when counts $<$ LTA - threshold)
Bi-directional sensing	Enables sensing in both directions	Application specific
Global Halt	Bit to globally halt LTA adjustment on all global halt enabled channels	Enable with use of sliders (IQS7222C)
Vref 0.5V Enable	Halves internal sampling capacitor size	Disable
Projected Bias select	Selection of bias current for mutual capacitive mode	Application specific
ATI Band	ATI will be executed if LTA moves outside this band	Application specific
Cs Size	Internal calibration capacitor size - used if the load is very small and the base value can not be set by using the maximum multiplier	40pF

Channel Enable	Enable/disabled channel	Application specific

2.3.1 IQS7222B Self-capacitive Channel Setup

The following example shows the settings to enable 8 self-capacitive channels with wake-up channels on channel 0 and channel 10 for the IQS7222B. Refer to table 1.4 for relationship between cycles and channels.

Table 2.3: Self-capacitive Example Setup for IQS7222B

Setting			Recommended Value
Cycles	Cycle 0	Tx Select	Tx0, Tx1, Tx2, Tx3, Tx4, Tx5, Tx6, Tx7
	Cycle 1		Tx0 + Tx4
	Cycle 2		Tx1 + Tx5
	Cycle 3		Tx2 + Tx6
	Cycle 4		Tx3 + Tx7
Channels	Channel 0	Rx Select	Rx0, Rx1, Rx2, Rx3
	Channel 1		Rx0
	Channel 2		Rx1
	Channel 3		Rx2
	Channel 4		Rx3
	Channel 10		Rx4, Rx5, Rx6, Rx7
	Channel 11		Rx4
	Channel 12		Rx5
	Channel 13		Rx6
	Channel 14		Rx7

2.3.2 IQS7222A & IQS7222C Self-capacitive Channel Setup

The following example shows the settings to enable 8 self-capacitive channels with wake-up channels on channel 0 and channel 5 for the IQS7222A & IQS7222C. Refer to table 1.5 for relationship between cycles and channels.

Table 2.4: Self-capacitive Example Setup for IQS7222A & IQS7222C

Setting			Recommended Value
Cycles	Cycle 0	Tx Select	Tx0, Tx1, Tx2, Tx3, Tx4, Tx5, Tx6, Tx7
	Cycle 1		Tx0 + Tx4
	Cycle 2		Tx1 + Tx5
	Cycle 3		Tx2 + Tx6
	Cycle 4		Tx3 + Tx7
Channels	Channel 0	Rx Select	Rx0, Rx1, Rx2, Rx3
	Channel 1		Rx0
	Channel 2		Rx1
	Channel 3		Rx2
	Channel 4		Rx3
	Channel 5		Rx4, Rx5, Rx6, Rx7
	Channel 6		Rx4
	Channel 7		Rx5
	Channel 8		Rx6
	Channel 9		Rx7

3 Mutual Capacitive Sensing

3.1 Principle of Mutual Capacitive Sensing

Electrically charged conductive objects close to one another will form an E-field. Unlike the self-capacitive technology, mutual capacitive technology measures the change in capacitive coupling between 2 electrodes. The coupling between the electrodes is called mutual capacitance / Cm and the electrodes are called the transmitter (CTx) and receiver (CRx).

- As a finger (conductive object) approach and the electrodes couple more with the finger, it effectively "steals" some of the charge. This will result in the C_M between the electrodes to decrease.
- Q = CV. With C_M decreasing, it will yield the charge (Q) per transfer will decrease
- This will increase the amount of transfers required to transfer the same amount of charge. Therefore counts go up when touching projected applications.

3.2 Electrode Layout for Mutual Capacitive Sensing

Please refer to application note AZD036

3.3 Configuring IQS7222x Device for Mutual Capacitive Sensing

Table 3.1: Cycle Settings for Mutual Capacitive Sensing

Setting	Description	Recommended Value
PXS Mode	Cycle mode	Mutual capacitive
Conversion Frequency Fraction	Frequency fraction relates to charge transfer frequency	127
Conversion Frequency Period	Determines the charge transfer frequency	Decimal value that results in f_{xfer} = 1MHz (refer to relevant datasheet)[1]
Tx Selection	Select to enable desired Tx	
Ground Inactive Rx's	Ground or float unused Rx's	Ground
Dead Time Enable	Enable dead time - period between the time the external load is changed and just before the input to the prox engine is opened to let the charge flow into the CS cap	Enable
F_{OSC} Tx Frequency	Enable F_{OSC} as charge transfer frequency (enable for inductive sensing)	Disable
V_{bias} enable	Enable Vbias (constant voltage drive onto CTx8) for resonant inductive sensing	Disable
Maximum Counts	Maximum count value	Application specific
Auto Mode	Number of conversions before each interrupt is generated	Application specific
ATI parameters Preload	Preloads from which the device will determine ATI parameters	Application specific
Current reference trim	Determine current source output value	0
Current reference level		0
Current reference output	Enable Current source output	None
Current reference enable	Enable source current	Disable

[1] For hardware versions 0xF003 or lower, the maximum charge transfer frequency is 1MHz

Table 3.2: Channel Settings

Setting	Description	Recommended Value
Rx Selection	Select to enable desired Rx	CRx0 to CRx7
Prox Threshold	Value at which a prox event will be triggered	Application specific
Touch Threshold	Value at which a touch event will be triggered $\text{Threshold} = \frac{\text{8-bit value} * LTA}{256}$	Application specific
Touch Hysteresis	Hysteresis value on touch release $\text{Release Threshold} = \frac{\text{LTA} * \text{Threshold bit value}}{2^8} - \frac{\text{Threshold bit value} * \text{Hysteresis bit value} * \text{LTA}}{2^{16}}$	Application specific
Proximity event timeouts	Channel state will timeout (channel counts will reseed to the LTA value) after chosen time value	Application specific
Touch event timeouts	Channel state will timeout (channel counts will reseed to the LTA value) after chosen time value	Application specific
Enter debounce value	Debounce factor before entering touch/prox state	Application specific
Exit debounce value	Debounce factor before exiting touch/prox state	Application specific
ATI Mode	Auto tuning implementation mode	> Full ATI > ATI from compensation only > ATI from compensation divider > ATI from fine fractional divider > ATI from coarse fractional divider > ATI disabled
ATI Base	Base value for ATI, influences sensitivity. Lower base value will increase sensitivity	Application specific
ATI Target	Target value for ATI, influences sensitivity. Lower target value will decrease sensitivity	Application specific
ATI Parameters	Parameters that can be adjusted to reach the specified ATI target and base > Compensation > Compensation divider > Coarse fractional multiplier > Coarse fractional divider > Fine fractional divider	Refer to relevant IQS7222x datasheet
Invert direction	Bit to set direction of sensing	Enable (activation when Counts $>$ LTA + threshold)
Bi-directional sensing	Enables sensing in both directions	Application specific
Global Halt	Bit to globally halt LTA adjustment on all global halt enabled channels	Enable with use of sliders (IQS7222C)
Vref 0.5V Enable	Halves internal sampling capacitor size	Disable
Projected Bias select	Selection of bias current for mutual capacitive mode	Application specific
ATI Band	ATI will be executed if LTA moves outside this band	Application specific
Cs Size	Internal calibration capacitor size - used if the load is very small and the base value can not be set by using the maximum multiplier	Application specific
Channel Enable	Enable/disabled channel	Application specific

3.3.1 IQS7222B Mutual Capacitive Channel Setup

The following example shows the settings to enable 18 mutual capacitive channels with wake-up channels on channel 0 and channel 10 for the IQS7222B, as shown in figure 3.1. Refer to table 1.4 for relationship between cycles and channels.

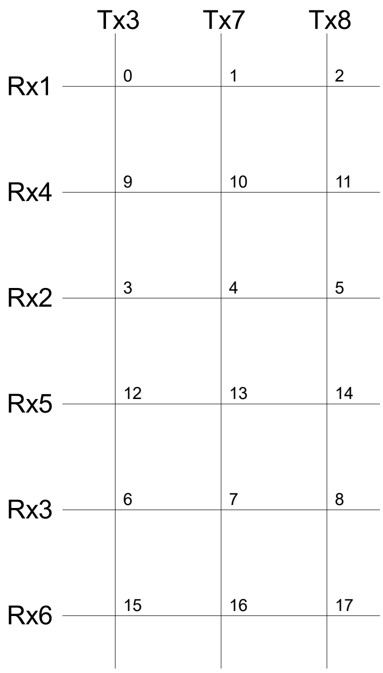

Figure 3.1: 18 Button Mutual Capacitive Setup

Table 3.3: Mutual Capacitive Example Setup for IQS7222B

Setting			Recommended Value
Cycles	Cycle 0	Tx Select	CTx3, CTx7, CTx8
	Cycle 1		CTx3
	Cycle 2		CTx7
	Cycle 3		CTx8
	Cycle 4		CTx3
	Cycle 5		CTx7
	Cycle 6		CTx8
	Cycle 7		CTx3
	Cycle 8		CTx7
	Cycle 9		CTx8
Channels	Channel 0	Rx Select	CRx0, CRx1, CRx2
	Channel 1		CRx1
	Channel 2		CRx1
	Channel 3		CRx1
	Channel 4		CRx2
	Channel 5		CRx2
	Channel 6		CRx2
	Channel 7		CRx3
	Channel 8		CRx3
	Channel 9		CRx3
	Channel 10		CRx4, CRx5, CRx6
	Channel 11		CRx4
	Channel 12		CRx4
	Channel 13		CRx4
	Channel 14		CRx5
	Channel 15		CRx5
	Channel 16		CRx5
	Channel 17		CRx6
	Channel 18		CRx6
	Channel 19		CRx6

3.3.2 IQS7222A & IQS7222C Mutual Capacitive Channel Setup

The following example shows the settings to enable 10 mutual capacitive channels for the IQS7222A and IQS7222C. Refer to table 1.5 for relationship between cycles and channels.

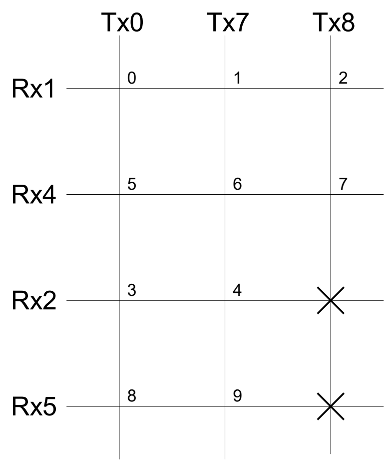

Figure 3.2: 10 Button Mutual Capacitive Setup

Table 3.4: Mutual Capacitive Example Setup for IQS7222A & IQS7222C

Setting			Recommended Value
Cycles	Cycle 0	Tx Select	CTx0
	Cycle 1		CTx7
	Cycle 2		CTx8
	Cycle 3		CTx3
	Cycle 4		CTx7
Channels	Channel 0	Rx Select	CRx1
	Channel 1		CRx1
	Channel 2		CRx1
	Channel 3		CRx2
	Channel 4		CRx2
	Channel 5		CRx4
	Channel 6		CRx4
	Channel 7		CRx4
	Channel 8		CRx5
	Channel 9		CRx5

4 Resonant Inductive Sensing

4.1 Principle of Resonant Inductive Sensing

By placing a capacitor and inductor in parallel as shown in fig. 4.1, an *LC tank* is formed. This circuit has a resonant frequency f_{res}. The resonant frequency is dependent on the value of the inductor and capacitor. Thus, by keeping the capacitor C fixed, a change in the inductance L can be detected by measuring a shift in the resonant frequency. This is done by driving the T_x node close to the resonant frequency and measuring the amplitude of V_{tank}.

When a metal object approaches the inductor, eddy currents are formed in the object. This causes the frequency response of the *LC Tank* to shift and results in a decrease in the amplitude of V_{tank}. Azoteq's ProxFusion® and ProxSense® ICs drive the T_x node and measure the amplitude of V_{tank} at the R_x node in order to measure the change in the inductance L. In this way, the presence of a metal object near the inductor can be detected.

Typical applications for inductive sensors include waterproof snap-dome buttons and metal flex force sensors.

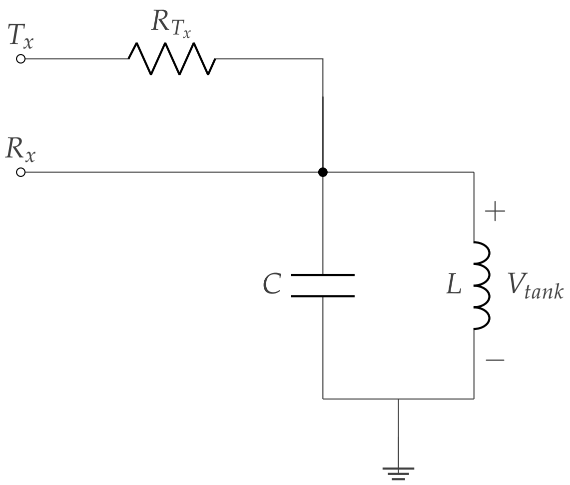

Figure 4.1: LC Tank Circuit for Resonant Inductive Sensing

4.2 Coil Design for Resonant Inductive Sensing

Please refer to application note AZD115

4.3 Configuring IQS7222x Device for Resonant Inductive Sensing

4.3.1 Biased Resonant Inductive Sensing Cycle Settings

Table 4.1: Cycle Settings for Resonant Biased Inductive Sensing

Setting	Description	Recommended Value
PXS Mode	Cycle mode	Inductive
Conversion Frequency Fraction	Frequency fraction relates to charge transfer frequency	127
Conversion Frequency Period	Determines the charge transfer frequency	Decimal value that results in f_{xfer} = 1MHz (refer to relevant datasheet)
Tx Selection	Select to enable desired Tx	Select TX connected to coil
Ground Inactive Rx's	Ground or float unused Rx's	Ground
Dead Time Enable	Enable dead time - period between the time the external load is changed and just before the input to the prox engine is opened to let the charge flow into the CS cap	Disable
F_{OSC} Tx Frequency	Enable F_{OSC} as charge transfer frequency (enable for inductive sensing)	Enable
V_{bias} enable	Enable Vbias (constant voltage drive onto CTx8) for resonant inductive sensing	Enable
Maximum Counts	Maximum count value	Application specific
Auto Mode	Number of conversions before each interrupt is generated	Application specific
ATI parameters Preload	Preloads from which the device will determine ATI parameters	Application specific
Source current Trim	Determine current source output value	0
Source current Level		0
Trim output select	Select source current output	None
Current enable	Enable source current	Disable

4.3.2 Direct Resonant Inductive Sensing Cycle Settings

Table 4.2: Cycle Settings for Direct Resonant Inductive Sensing

Setting	Description	Recommended Value
PXS Mode	Cycle mode	Mutual inductive
Conversion Frequency Fraction	Frequency fraction relates to charge transfer frequency	127
Conversion Frequency Period	Determines the charge transfer frequency	Decimal value that results in f_{xfer} = 2MHz (refer to relevant datasheet)
Tx Selection	Select to enable desired Tx	Select TX connected to coil
Ground Inactive Rx's	Ground or float unused Rx's	Ground
Dead Time Enable	Enable dead time - period between the time the external load is changed and just before the input to the prox engine is opened to let the charge flow into the CS cap	Disable
F_{OSC} Tx frequency	Enable F_{OSC} as charge transfer frequency	Disable
V_{bias} enable	Enable Vbias (constant voltage drive onto CTx8) for resonant inductive sensing	Disable
Maximum Counts	Maximum count value	Application specific
Auto Mode	Number of conversions before each interrupt is generated	Application specific
ATI parameters Preload	Preloads from which the device will determine ATI parameters	Application specific
Current reference trim	Determine current source output value	0
Current reference level		0
Current reference output	Enable Current source output	None
Current reference enable	Enable source current	Disable

4.3.3 Resonant Inductive Sensing Channel Settings

The channel settings for the IQS7222x biased and direct resonant inductive sensing are similar as is shown in table 4.2

Table 4.3: Channel Settings for Resonant Inductive Sensing

Setting	Description	Recommended Value
Rx Selection	Select to enable desired Rx	CRx1 to CRx6
Prox Threshold	Value at which a prox event will be triggered	Application specific
Touch Threshold	Value at which a touch event will be triggered $\text{Threshold} = \frac{\text{8-bit value} * LTA}{256}$	Application specific
Touch Hysteresis	Hysteresis value on touch release $\text{Release Threshold} = \frac{\text{LTA * Threshold bit value}}{2^8} - \frac{\text{Threshold bit value * Hysteresis bit value *LTA}}{2^{16}}$	Application specific
Proximity event timeouts	Channel state will timeout (channel counts will reseed to the LTA value) after chosen time value	Application specific
Touch event timeouts	Channel state will timeout (channel counts will reseed to the LTA value) after chosen time value	Application specific
Enter debounce value	Debounce factor before entering touch/prox state	Application specific
Exit debounce value	Debounce factor before exiting touch/prox state	Application specific
ATI Mode	Auto tuning implementation mode	> Full ATI > ATI from compensation only > ATI from compensation divider > ATI from fine fractional divider > ATI from coarse fractional divider > ATI disabled
ATI Base	Base value for ATI, influences sensitivity. Lower base value will increase sensitivity	Application specific
ATI Target	Target value for ATI, influences sensitivity. Lower target value will decrease sensitivity	Application specific
ATI Parameters	Parameters that can be adjusted to reach the specified ATI target and base > Compensation > Compensation divider > Coarse fractional multiplier > Coarse fractional divider > Fine fractional divider	Refer to relevant IQS7222x datasheet
Invert direction	Bit to set direction of sensing	Enable (activation when Counts > LTA + threshold)
Bi-directional sensing	Enables sensing in both directions	Application specific
Global Halt	Bit to globally halt LTA adjustment on all global halt enabled channels	Enable with use of sliders (IQS7222C)
Vref 0.5V Enable	Halves internal sampling capacitor size	Disable
Projected Bias select	Selection of bias current for mutual capacitive mode	Application specific
ATI Band	ATI will be executed if LTA moves outside this band	Application specific
Cs Size	Internal calibration capacitor size - used if the load is very small and the base value can not be set by using the maximum multiplier	40pF
Channel Enable	Enable/disabled channel	Application specific

5 Slider User Interface

The IQS7222A and IQS7222C both have 2 sliders. Both sliders can use 3 or 4 elements and the sliders on the IQS7222C can be configured as wheels. The IQS7222B does not have a slider UI, but a filter halt bit can be enabled to allow for slider calculations on the MCU.

5.1 Slider Layout

5.2 Slider Combinations for IQS7222A

The IQS7222A slider UI allows for the following combinations:

- 2 x 3 element mutual capacitive sliders
- 2 x 4 element self-capacitive sliders
- 1 x 4 element mutual capacitive slider

5.3 Slider/ Wheel Combinations for IQS7222C

The IQS7222C slider UI allows for the following combinations:

- 2 x 3 element mutual capacitive sliders/wheels
- 2 x 4 element self-capacitive sliders/wheels
- 1 x 4 element mutual capacitive slider/wheel

5.4 Configuring the IQS7222A & IQS7222C for Sliders

The following slider settings are available on the IQS7222A and IQS7222C:

Table 5.1: Slider Settings

Setting	Description	Options
Resolution	Determines precision of slider	16-bit value (IQS7222C) 8-bit value * 16 (IQS7222A)
Lower calibration value	Value to determine where the lower starting point of the slider is.	8-bit value. Set to 0 for wheels.
Upper calibration value	Value to determine where the upper starting point of the slider is.	8-bit value. Set to 0 for wheels.
Slow/static filter	Fixed or adjustable damping (beta) factor	Enable: Static filter with fixed damping factor (beta) used at all speeds Disabled: Dynamic filter with adjustable damping factor (beta) between configurable bottom and top speed settings.
Wheel enable (**only available on IQS7222C**)	Configure slider as wheel	Enable or disable
Total channels	Total channels/elements per slider	3 4 Disabled
Bottom filter speed	Filter value = beta (more filtering) for slow movement. Movement speeds above bottom speed value and below top speed value will result in a linear filter damping factor	8-bit value Refer to table 5.1 for a graphic description
Top filter speed	Filter value = 0 (no filtering) for fast movement. Movement speeds below top speed value and above bottom speed value will result in a linear filter damping factor	8-bit value (IQS7222A), 16-bit value (IQS7222C) Refer to table 5.1 for a graphic description
Slider channel enable mask	Enable channels for slider	Select all channels in use for slider
Enable status link	Set slider output to trigger on proximity or touch event	Proximity Touch
Delta link	Link channel to slider element	Select CH0 to CH9

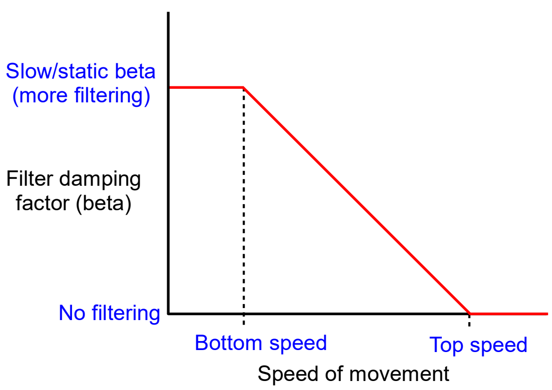

Figure 5.1: Dynamic Filter Parameters

5.4.1 Example for 3 Element Self-capacitive Slider

For channel setup, refer to table 2.4. To change the three element slider below, to a wheel, simply set the wheel enable bit.

Table 5.2: Three Element Slider Settings

Setting	Description	Recommended Value
Resolution	Determines precision of slider	Application specific.
Lower calibration value	Value to determine where the lower starting point of the slider is.	Application specific.
Upper calibration value	Value to determine where the upper starting point of the slider is.	Application specific
Slow/static filter	Fixed or adjustable damping (beta) factor	Application specific.
Wheel enable	Configure slider as wheel	Disable
Total channels	Total channels/elements per slider	3
Bottom filter speed	Pixels per cycle where filter damping is no longer equal to beta and becomes dynamic	Application specific
Top filter speed	Pixels per cycle where filter damping is no longer dynamic and becomes 0	Application specific
Slider channel enable mask	Enable channels for slider	Select channel 1, 2, 3
Enable status link	Set slider output to trigger on proximity or touch event	Proximity
Delta link 0	Link channel 1 to the first slider element	CH1(Refer to datasheet)
Delta link 1	Link channel 2 to the second slider element	CH2(Refer to datasheet)
Delta link 2	Link channel 3 to the third slider element	CH3(Refer to datasheet)
Delta link 3	Slider only has 3 elements	None (0)

5.5 IQS7222A Slider Gestures

The IQS7222A provides tap, swipe and flick slider gestures. The following settings are available for sliders:

Please note that all gesture settings are application specific.

It is necessary to release all touches before any new gesture can be made and validated.

Table 5.3: Slider Event Settings

Setting	Description	Options
Tap gesture enable	Enable/disable tap events	Enable or disabled
Swipe gesture enable	Enable/disable swipe events	Enable or disabled
Flick gesture enable	Enable/disable flick events	Enable or disabled
Minimum tap time	Time value that needs to be exceeded for a tap event to be registered	5-bit value
Maximum tap time	Tap event: minimum swipe distance not exceeded and touch released before time value is reached Swipe event: minimum swipe distance and maximum tap time is exceeded If neither of the above conditions are met, no event will be registered	8-bit value
Maximum swipe time	No swipe, flick or tap event will be registered if this time value is exceeded	8-bit value
Minimum swipe distance	Number of pixels that must be exceeded, along with reaching the maximum tap time value and without exceeding the maximum swipe time, to register a swipe event	8-bit value

6 Reference Channel User Interface

The IQS7222A and IQS7222C offers a reference channel UI.

Due to the small capacitance changes in some applications (compared to the larger system capacitance) it is recommended to use a "reference channel" approach in certain applications.

A reference channel adjusts the LTA of the primary sensing channel by subtracting the change in LTA of the reference channel from the LTA of the primary sensing channel to prevent a drastic change in delta. The reference channel sensor should be exposed to the same conditions, but the user should not be able to affect the counts of the channel.

The figure below shows the effect of temperature change on the delta produced by touch. The graph shows that a reference channel limits the effect of temperature on the delta (shown in green) compared to the effect of temperature on the delta when no reference channel is activated (shown in yellow). The limited change in delta when using a reference channel is particularly valuable in wear-detection applications, where the temperature is likely to change over time.

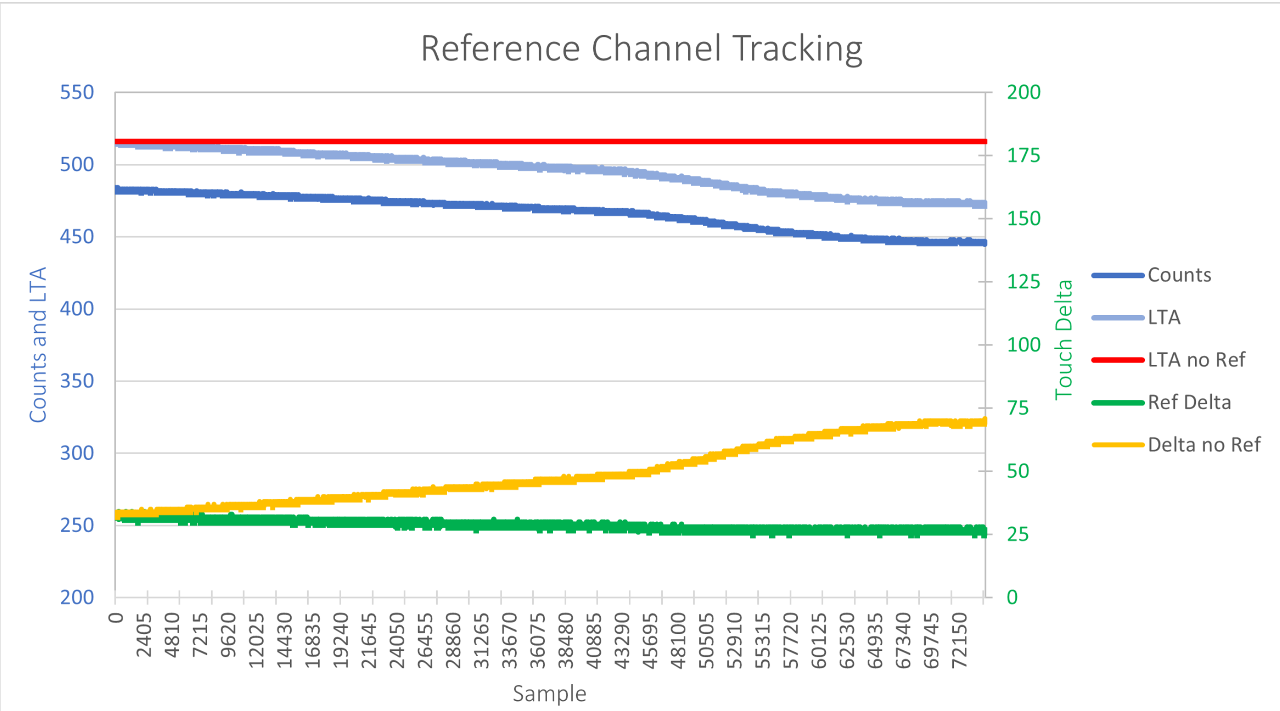

Figure 6.1: Reference Channel

6.1 Reference Channel Configuration

Table 6.1: Reference Channel UI Settings

Setting	Description	Options
Channel mode	Configure channel as reference or follower	Independent Reference Follower
Proximity event timeouts	Channel state will timeout Touch event timeouts after chosen time value	0 - 127.5 seconds
Touch event timeouts	Channel state will timeout Touch event timeouts after chosen time value	0 - 127.5 seconds
Reference Follower Mask Ptr	If channel is set as reference channel, this register determines if the reference UI will activate on Proximity or Touch event	Proximity (Refer to datasheet for value) Touch (Refer to datasheet for value)
Sensor Mask	If channel is set as follower channel, this register determines the channel that will serve as a reference channel for the channel	CH0 to CH9 (only a single channel can be selected)
Reference Follower Mask	If channel is set as reference channel, this register determines the channel(s) that will follow the channel	CH0 to CH9 (Multiple channels can be selected)
Reference Weight	If channel is set as follower channel, this value determines the rate at which the follower channel will follow the reference channel adjustment	Bit value/256

6.2 Reference Channel Example Setup

For self-capacitive channel setup, refer to table 2.4. For mutual capacitive channel setup, refer to table 3.2.

Table 6.2: Reference Channel UI Example Settings - Reference Channel

Reference Channel e.g Channel 0

Setting	Description	Options
Channel mode	Configure channel as reference or follower	Reference
Proximity event timeouts	Channel state will timeout after chosen time value	0 (never timeout)
Touch event timeouts	Channel state will timeout after chosen time value	0 (never timeout)
Reference Follower Mask Ptr	Reference channel tracking will start on Touch event	Touch (Refer to datasheet for value)
Reference Follower Mask	Select channels for which this channel will serve as a reference	CH1, CH2, CH3 (Refer to datasheet for value)

Table 6.3: Reference Channel UI Example Settings - Follower Channel

Follower Channel e.g Channel 1, 2, 3

Setting	Description	Options
Channel mode	Configure channel as reference or follower	Follower
Proximity event timeouts	Channel state will timeout after chosen time value	0 (never timeout)
Touch event timeouts	Channel state will timeout after chosen time value	0 (never timeout)
Sensor Mask	Select channel that will serve as a reference channel for the channel	CH0 (Refer to datasheet for value)
Reference Weight	Value that determines the rate at which the follower channel will follow the reference channel adjustment	100% (0x100)

7 GPIO User Interface

7.1 IQS7222C GPIO Setup

The IQS7222C offers three GPIO outputs with the option to use the GPIO as a direct output. The following settings can be set separately for each of the three GPIO outputs:

Table 7.1: IQS7222C GPIO Settings

Setting	Description	Options
GPIO enabled	Enable or disable GPIO output	Enable or disabled
GPIO linked to output	Select the GPIO linked to the output (more than one GPIO can be selected for the same output)	GPIO0, GPIO3 and GPIO4
Output configuration	Select logic of the GPIO output	Push pull active high Open drain active low
Channel enable mask	Select channel on which the GPIO output will trigger	CH0 to CH10 (Multiple channels can be selected)
Enable status link	Set GPIO output to trigger on proximity or touch event	Proximity Touch Direct (Refer to GPIO override setting below)
GPIO Override	Set bits corresponding to the GPIO output on which status link is set to "Direct Output"to directly override the GPIO output state	CH0, CH1, CH2

7.2 IQS7222A GPIO Setup

The IQS7222A offers one GPIO output with the option to trigger on proximity or touch events. The following settings are applicable to the GPIO output:

Table 7.2: IQS7222A GPIO Settings

Setting	Description	Options
GPIO enabled	Enable or disable GPIO output	Enable or disabled
Output configuration	Select logic of the GPIO output	Push pull active high Open drain active low
Channel enable mask	Select channel on which the GPIO output will trigger	CH0 to CH9 (Multiple channels can be selected) Tap, swipe or flick event (Multiple events can be selected)
Enable status link	Set GPIO output to trigger on proximity, touch or slider event	Proximity Touch Slider 0 Slider 1

8 Hall-effect User Interface

Hall effect sensing is an internal sensing option on the IQS7222A that requires no external sensor design.

The Hall effect switch UI measures the magnetic field induced on the hall plate of the IC and is, by default, activated when both Hall-effect channels (channel 10 and channel 11) are active. The UI uses two channels to determine the magnetic field induced on the Hall plate. Using two channels ensures that the ATI can still be used in the presence of the magnet. An inverted channel allows the capability of calculating a reference value which will always be the same regardless of the presence of a magnet. Enabling the UI will enable the IC to display the effects of the magnet by reading the data in the Hall UI flags and output registers.

The Hall effect switch UI is used for detection of the presence of a single magnet.

There are two channel outputs and each channel controls different parameters of the Hall effect. Please note that parameters not listed under the relevant channel's setting, below, must be left as default.

Channel 10 output is the signal output, calculated using:

$$\text{Channel } 10_{\text{output}} = \frac{Counts - Counts_{\text{inv}}}{2}$$

Channel 11 output is the LTA and signal without the output on Channel 10, calculated using:

$$\text{Channel } 11_{\text{output}} = \frac{Counts + Counts_{\text{inv}}}{2}$$

Channel 11 allows ATI to be performed without changing the count value on Channel 10.

Table 8.1: General Settings only available for Hall-effect on IQS7222A

Setting	Description	Options
Hall coarse offset	Coarse offset current in 3μA steps	-21μA to 21μA
Hall fine offset	Fine offset current in 200nA steps	4-bit value * 200nA

Table 8.2: Hall-effect Cycle Settings

Setting	Description	Recommended Value	Relevant Channel
PXS Mode	Cycle mode	Fixed - do not change	Channel 10 & 11
Conversion Frequency Fraction	Frequency fraction relates to charge transfer frequency	127	Channel 10 & 11
Conversion Frequency Period	Determines the charge transfer frequency	Decimal value that results in f_{xfer} = 2MHz (refer to relevant datasheet)	Channel 10 & 11
Tx Selection	Select to enable desired Tx	NA	NA
Ground Inactive Rx's	Ground or float unused Rx's	Enable	Channel 10 & 11
Dead Time Enable	Enable dead time - period between the time the external load is changed and just before the input to the prox engine is opened to let the charge flow into the CS cap	Disabled	Channel 10 & 11
F_{OSC} Tx frequency	Enable F_{OSC} as charge transfer frequency (enable for inductive sensing)	Disabled	NA
V_{bias} enable	Enable Vbias (constant voltage drive onto CTx8) for resonant inductive sensing	Disabled	NA
Maximum Counts	Maximum count value	Application specific	NA
Auto Mode	Number of conversions before each interrupt is generated	Application specific	NA
ATI parameters Preload	Preloads from which the device will determine ATI parameters	Application specific	NA
Hall coarse offset	Coarse offset current in 3μA steps	Application specific	NA
Hall fine offset	Fine offset current in 200nA steps	Application specific	NA

Table 8.3: Hall-effect Channel Settings

Setting	Description	Options	Relevant Channel
Rx Selection	Select to enable desired Rx	NA	NA
Prox Threshold	Value at which a prox event will be triggered	Application specific	Channel 10
Touch Threshold	Value at which a touch event will be triggered	Application specific	Channel 10
Touch Hysteresis	Hysteresis value on touch release	Application specific	Channel 10
Proximity event timeouts	Channel state will timeout after chosen time value	Application specific	Channel 10
Touch event timeouts	Channel state will timeout after chosen time value	Application specific	Channel 10
Enter debounce value	Debounce factor before entering touch/prox state	Application specific	Channel 10
Exit debounce value	Debounce factor before exiting touch/prox state	Application specific	Channel 10
ATI Mode	Auto tuning implementation mode	› Full ATI	Channel 10 & 11

		› ATI from compensation only › ATI from compensation divider › ATI from fine fractional divider › ATI from coarse fractional divider › ATI disabled	
ATI Base	Base value for ATI, influences sensitivity. Lower base value will increase sensitivity	Application specific	Channel 10 & 11
ATI Target	Target value for ATI, influences sensitivity. Lower target value will decrease sensitivity	Application specific	Channel 10 & 11
ATI Parameters	Parameters that can be adjusted to reach the specified ATI target and base › Compensation › Compensation divider › Coarse fractional multiplier › Coarse fractional divider › Fine fractional divider	Refer to relevant IQS7222x datasheet	Channel 11
Invert direction	Bit to set direction of sensing	NA	NA
Bi-directional sensing	Enables event triggering in both directions (counts > LTA & counts < LTA)	NA	NA
Global Halt	Bit to globally halt LTA adjustment on all global halt enabled channels	NA	NA
Vref 0.5V Enable	Halves internal sampling capacitor size	Disable	Channel 10 & 11
Projected Bias select	Selection of bias current for mutual capacitive mode	NA	NA
ATI Band	ATI will be executed if LTA moves outside this band	Application specific	Channel 11
Cs Size	Internal calibration capacitor size - used if the load is very small and the base value can not be set by using the maximum multiplier	Application specific	Channel 10 & 11
Channel Enable	Enable/disabled channel	Application specific	Channel 10 & 11

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