IQS242 Datasheet - Minimalist 2 Channel Capacitive Sensor with Compensation for Sensitivity Reducing Objects

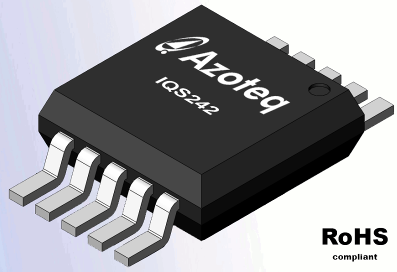
Unparallelled Features:

- ❏ Sub 4 µA current consumption
- ❏ Automatic tuning for optimal operation in various environments & compensation against sensitivity reducing objects

The IQS242 ProxSense® IC is a fully integrated two channel capacitive contact and proximity sensor with market leading sensitivity and automatic tuning of the sense electrode. The IQS242 provides a minimalist implementation requiring as few as 2 external components. The device is ready for use in a large range of applications while programming options allow customisation in specialised applications.

Main features:

MSOP-10



RoHS compliant

- ❏ 2 Channel Input device
- ❏ Differentiated Touch and Proximity Electrodes with DYCAL™
- ❏ ATI: Automatic tuning to optimum sensitivity
- ❏ Supply Voltage1.8 V to 3.6 V
- ❏ Internal voltage regulator and reference capacitor
- ❏ OTP options available
- ❏ Direct (logic level) and serial data output
- ❏ Low Power Modes (sub 4 µA min)
- ❏ Proximity & Touch Thresholds
- ❏ Automatic drift compensation
- ❏ Development and Programming tools available
- ❏ Small outline MSOP-10

Applications:

- ❏ White goods and appliances
- ❏ Remote Controls
- ❏ Office equipment, toys, sanitary ware
- ❏ Flame proof, hazardous environment Human Interface Devices
- ❏ Proximity detection that enables back lighting activation (Patented)
- ❏ Wake-up from standby applications
- ❏ Replacement for electro-mechanical switches
- ❏ GUI trigger on proximity detection.

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Revision History

Rev	Description	Date
0.01	Preliminary	March 2012
1.00	Firts Release	June 2012

List of Symbols

1 Functional Overview

The IQS242 is a two channel capacitive proximity and touch sensor featuring an internal voltage regulator and reference capacitor (Cs). The device has two dedicated input pins for the connection of the sense electrode (CX). Two output pins for Touch (for each channel) detection and two outputs (PO) for proximity detection on both channels. The output pins can be configured as Logic outputs or in a serial data streaming option on TO0 (data) and TO1 (clock). The device automatically tracks slow varying environmental changes via various filters, detect noise and has an Automatic Tuning Implementation (ATI) to tune the device for optimal sensitivity.

1.1 Pin Outs

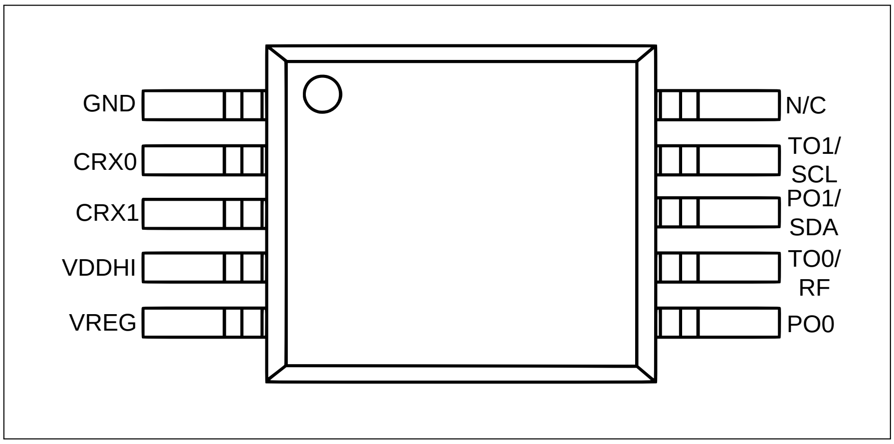


Figure 1.1: IQS242 pin-out.

The IQS242 is pin compatible with the IQS142, but has different electrical characteristics. Refer to Section 11.

Table 1.1: IQS242 Pin-outs

Pin	stand alone	Streaming	Function
1	GND	GND	Ground
2	CX1	CX1	Sense Electrode
3	CX0	CX0	Sense Electrode
4	VDDHI	VDDHI	Power Input
5	VREG	VREG	Regulator Pin
6	PO		Proximity Output /ND
7	TO0/RF	RDY	Touch Output /Data
8	PO1	SDA	Proximity Output /Clock
9	TO1	SCL	Touch Output /RDY
10			No Connect

1.2 Applicability

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

- ❏ Temperature −40 °C to +85 °C
- ❏ Supply voltage (VDDHI) 1.8 V to 3.6 V

2 Analogue Functionality

The analogue circuitry measures the capacitance of the sense electrodes attached to the Cx pins through a charge transfer process that is periodically initiated by the digital circuitry. The measuring process is referred to as a conversion and consists of the discharging of Cs and Cx, the charging of Cx and then a series of charge transfers from Cx to Cs until a trip voltage is reached. The number of charge transfers required to reach the trip voltage is referred to as the counts (C_S). The capacitance measurement circuitry makes use of an internal Cs and voltage reference (V_{REF}). 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 configuration 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 Reference Design

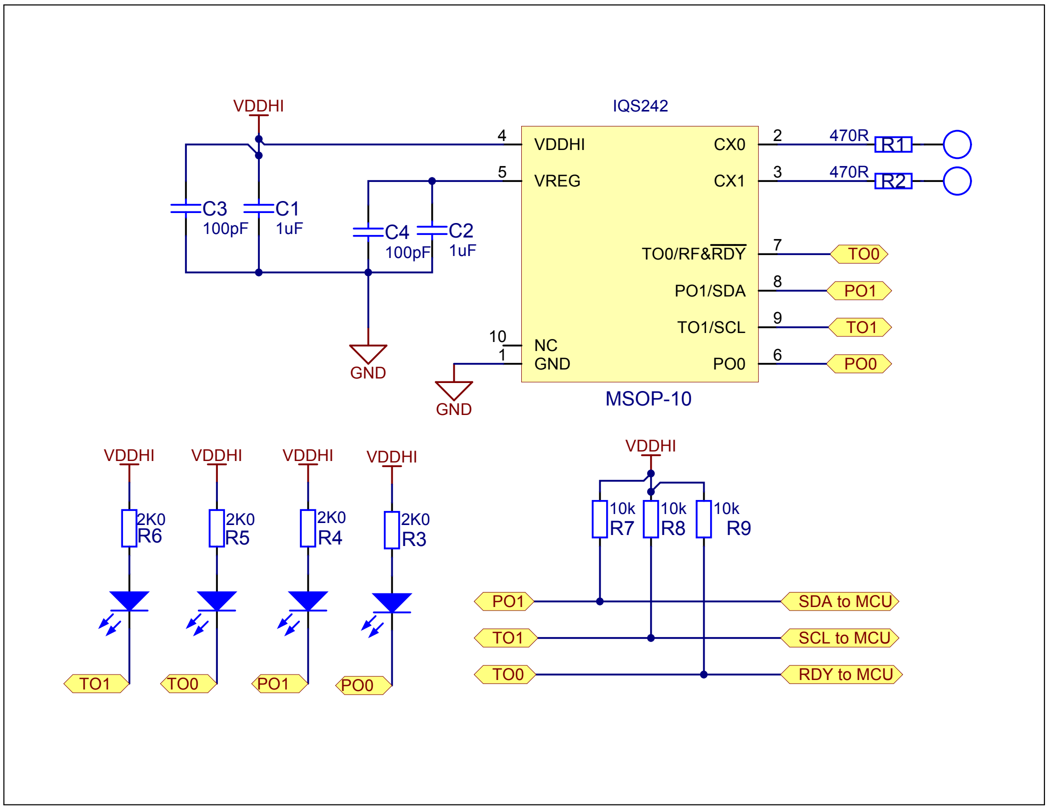


Figure 4.1: IQS242 Reference Design.

4.1 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 Section 11). 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 4.1 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.

4.2 Design Rules for Harsh EMC Environments

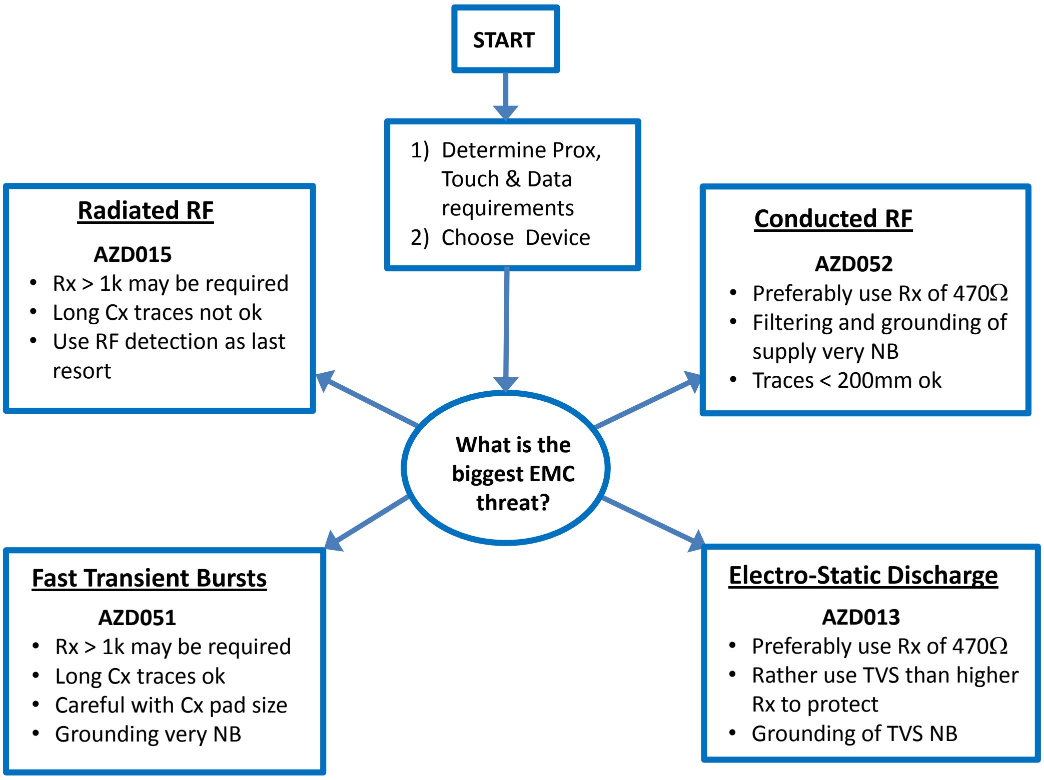


Figure 4.2: EMC Design Choices. Applicable application notes: [1], [2], [3], [4]

5 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 equalled 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 electrode and ground becomes too large the sensitivity of the device may be influenced. For more guidelines on layout, please refer to [5], available on the Azoteq web page, visit:

www.azoteq.com

6 User Configurable Options

The IQS242 provides One Time Programmable (OTP) user options (each option can be modified only once). The IQS232 can enter streaming mode (I^2C debuging) at start-up where the OTP options can be set and evaluated through the memory map, refer to Section A, before programming OTP setting for stand alone use. The device is fully functional in the default (unconfigured) state. OTP options are intended for specific applications. The configuration of the device can be done on packaged devices or in-circuit. In-circuit configuration may be limited by values of external components chosen.

6.1 Configuring of Devices

Azoteq offers a Configuration Tool (CT220 or later) and accompanying 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 is explained by [6]: "AZD007 - USBProg Overview" which can be found on the Azoteq website. Alternate programming solutions of the IQS242 also exist. For further enquiries regarding this matter please contact Azoteq at: ProxSenseSupport@azoteq.com or the local distributor.

Table 6.1: User Selectable Configuration Options: Bank 0

ATI	$P_{THR}1$	$P_{THR}0$	$T_{THR}2$	$T_{THR}1$	$T_{THR}0$	$P_{THR}1$	$P_{THR}0$
bit 7	Bank 0 - Normal Operation						bit 0

Bank 0: bit 7	**ATI:ATI method**	Section 7.1
	0 = Full 1 = Partial	
Bank 0: bit 6:5	**$P_{THR}1$:$P_{THR}1$: Proximity Threshold - CH1**	Section 7.5
	00 = 4 01 = 2 (Most Sensitive) 10 = 8 11 = 16 (Least Sensitive)	
Bank 0: bit 4:2	**$T_{THR}2$:$T_{THR}1$: Touch Thresholds CH1**	Section 7.4
	000 = 4/64 001 = 1/64 (Most Sensitive) 010 = 2/64 011 = 8/64 100 = 12/64 101 = 16/64 110 = 24/64 111 = 32/64 (Least Sensitive)	
Bank 0: bit 1:0	**$P_{THR}1$:$P_{THR}1$: Proximity Threshold - CH2**	Section 7.5
	00 = 4 01 = 2 (Most Sensitive) 10 = 8 11 = 16 (Least Sensitive)	

Table 6.2: User Selectable Configuration Options: Bank 0

ATI	Release THR	Output	$T_{THR}2$	$T_{THR}1$	$T_{THR}0$	$P_{THR}1$	$P_{THR}0$
bit 7	Bank 0 - Dycal Operation						bit 0

Bank 0: bit 7	**ATI:ATI method**	Section 7.1
	0 = Full 1 = Partial	
Bank 0: bit 6	**Release THR: Dycal Release Threshold**	Section 7.2
	0 = 75% 1 = 87.5%	
Bank 0: bit 5	**Output: Dycal Output Selection**	Section 7.3
	0 = Touch 1 = Proximity	
Bank 0: bit 4:2	**$T_{THR}2$:$T_{THR}1$: Touch Thresholds CH1 and CH2**	Section 7.4
	000 = 4/64 001 = 1/64 (Most Sensitive) 010 = 2/64 011 = 8/64 100 = 12/64 101 = 16/64 110 = 24/64 111 = 32/64 (Least Sensitive)	
Bank 0: bit 4:2	**$P_{THR}1$:$P_{THR}1$: Proximity Threshold**	Section 7.5
	00 = 4 01 = 2 (Most Sensitive) 10 = 8 11 = 16 (Least Sensitive)	

Table 6.3: User Selectable Configuration Options: Bank 1 (Full ATI)

$t_{HALT}1$	$t_{HALT}0$	Sys Use	$T_{THR}2$	$T_{THR}1$	$T_{THR}0$	BASE1	BASE0
bit 7	Bank 1 - Full ATI						bit 0

Bank 1: bit 7:6	**$t_{HALT}1$:$t_{HALT}0$: Halt time of Long Term Average**	Section 7.6
	00 = 18 seconds	
	01 = 72 seconds	
	10 = 3 seconds	
	11 = Always (Prox on 18)	
Bank 1: bit 5	**System Use**	
Bank 1: bit 4:2	**CH2 $T_{THR}2$:$T_{THR}0$: Touch Thresholds on CH2**	Section 7.4
	000 = 4/64	
	001 = 1/64 (Most Sensitive)	
	010 = 2/64	
	011 = 8/64	
	100 = 12/64	
	101 = 16/64	
	110 = 24/64	
	111 = 32/64 (Least Sensitive)	
Bank 1: bit 1:0	**BASE1:BASE0: ATI Base Values**	Section 7.7
	00 = 200 (150 with BASESEL set to Alternative)	
	01 = 50 (350 with BASESEL set to Alternative)	
	10 = 100 (500 with BASESEL set to Alternative)	
	11 = 250 (700 with BASESEL set to Alternative)	

Table 6.4: User Selectable Configuration Options: Bank 1 (Partial ATI)

$t_{HALT}1$	$t_{HALT}0$	MUL5	MUL4	MUL3	MUL2	MUL1	MUL0
bit 7	Bank 1 - Partial ATI						bit 0

Bank 1: bit 7:6	**$t_{HALT}1$:$t_{HALT}0$: Halt time of Long Term Average**	Section 7.6
	00 = 18 seconds	
	01 = 72 seconds	
	10 = 3	
	11 = Always (Prox on 18)	
Bank 1: bit 5:4	**MUL5:MUL4: Sensitivity Multipliers**	Section 7.8
	00 = Lowest	
	11 = Highest	
Bank 1: bit 3:0	**MUL3:MUL0: Base Multipliers**	Section 7.9
	0000 = Lowest	
	1111 = Highest	

Table 6.5: User Selectable Configuration Options: Bank 2

$Base_{SEL}$	T_{FRQ}	STREAMING	ND	PMODE1	PMODE0	UI Select	LOGIC
bit 7	Bank 2						bit 0

Bank 2: bit 7	**$Base_{SEL}$: Base Select**	Section 7.10
	0 = Default 1 = Alternative	
Bank 2: bit 6	**T_{FRQ}: Charge Transfer Frequency** 0 = 500kHz 1 = 1MHz	Section 7.11
Bank 2: bit 5	**STREAMING: 2-wire Streaming mode**	Section 7.12
	0 = Disabled 1 = Enabled	
Bank 2: bit 4	**ND: Noise Detect**	Section 7.13
	0 = Disabled 1 = Enabled	
Bank 2: bit 3:2	**PMODE1:PMODE0: Low Power Mode**	Section 7.14
	00 =9ms (Boost Power Mode) 01 = 32ms (Normal Power Mode) 10 = 128ms (Low Power 1) 11 = 1s (Low Power 2)	
Bank 2: bit 1	**UI Select: Operational Selection**	Section 7.15
	0 = Normal 1 = Dycal	
Bank 2: bit 0	**LOGIC: Output logic select**	Section 7.16
	0 = Active Low 1 = Active High	

Table 6.6: User Selectable Configuration Options: Bank 3

Sys Use	Sys Use	Sys Use	Sys Use	Sys Use	Sys Use	Delay	Target
bit 7	Bank 3						bit 0

Bank 3: bit 7:2	**Sys Use: System Use**	
Bank 3: bit 1	**Delay: ATI Delay After Prox cleared**	Section 7.17
	0 = 0 seconds 1 = 10 seconds	
Bank 3: bit 0	**Target: ATI Target Counts**	Section 7.18
	0 = 1000 1 = 500	

7 Description of User Options

This section describes the individual user programmable options of the IQS242 in more detail. Azoteq can supply pre-configured devices for large quantities.

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

7.1 ATI Method

The IQS242 can be setup to start in two ways; Full ATI and Partial ATI. In Full ATI mode, the device automatically select the multipliers through the ATI algorithm to setup the IQS242 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 IQS242 to only calculate the compensation (not the compensation and multipliers as in Full ATI), which allows the freedom to make the IQS242 more or less sensitive for its intended environment of use.

7.2 Release Threshold

When the IQS242 is configured to operate as a two channel Dycal device, there is the option to change the release threshold for 75% (default) to 87.5%. The higher release threshold is for use in applications where it is required for more movement from the use to the sensing electrodes before the device exits touch mode. The touch mode release threshold is calculated as follow:

$$Release_{THR} = SelectRelease\% \times T_{THR} \quad (7.1)$$

7.3 Output Select

When the IQS242 is configured to operate as a two channel Dycal device, the designer has the option to select Dycal Output (and and thus touch mode entry) upon the detection of a touch, or prox event. Halt times are only applicable on proximity events, when the Dycal output is selected on touch.

7.4 Touch Thresholds

The IQS242 has 8 touch threshold settings. The touch threshold is selected by the designer to obtain the desired touch sensitivity. The touch threshold is expressed as a fraction of the LTA as follows:

$$T_{THR} = SelectedValue \times LTA \quad (7.2)$$

Where LTA is the Long Term Average The touch event is triggered based on T_{TH}, CS and LTA. A touch event is identified when for at least 2 consecutive samples of the following equation holds:

$$T_{TH} =< LTA - CS \quad (7.3)$$

With lower average CS (therefore lower LTA) values the touch threshold will be lower and vice versa. Changing the target current samples of the touch channels, will also change the value of the LTA, which affect the counts required for a touch event. The Touch Threshold for CH1 is set in Bank 0, while the Touch Threshold for CH2 is set in Bank 1 (when in full ATI-mode).

7.5 Proximity Threshold

The IQS242 has 4 proximity threshold 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; the CS and LTA (Long Term Average). The threshold is expressed in terms of counts; the same as CS. For a proximity event, the CS (counts) of the prox channel should fall the P_{TH} value below the LTA for at least 6 consecutive samples.

7.6 Halt time

The Halt Timer is started when a proximity or touch event occurs and is restarted when an event is removed or reoccurs. When a proximity condition occurs on any of the channels, the LTA 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}). If the timer expires, all outputs will be cleared. It is possible that the CS could be outside the ATI band (Target +- 160 or +- 80) when the timer expires, which will cause a re-ATI event. The designer needs to select a Halt Timer value to best accommodate the required application.

18 seconds The halt timer will halt for 18 seconds after the last proximity or touch event.

72 seconds The halt timer will halt for 72 seconds after the last proximity or touch event.

3 seconds The halt timer will halt for 3 seconds after the last proximity or touch event.

Always With the 'ALWAYS' option, the detection of a proximity event will halt the LTA for only 18 seconds and with the detection of a touch event will halt the LTA for as long as the touch condition applies.

Halt times are not applicable when the IQS242 enters touch mode upon proximity or touch events.

7.7 Base Values

The IQS242 has the option to change the Base Value of both channels during the ATI algorithm. Depending on the application, this provides the user with another option to select the sensitivity of the IQS242 without changes in the hardware (CX sizes and routing, etc). There are 4 available options, with another 4 options becoming available when the BASESEL bit is set to alternative.

7.8 Sensitivity Multipliers

Sensitivity multipliers are added after the base value is selected through the base multipliers. If the sensitivity multipliers are selected high, the ATI algorithm could reach the target for current samples without adding any compensation, thus rendering the device less sensitive. For the same reasoning, setting the sensitivity multipliers low, will add more compensation, and increase the device sensitivity.

7.9 Base Multipliers

Base multipliers selects the base value of the ATI algorithm. Thus, if lower values are selected, the algorithm needs to add more sensitivity multipliers and compensation to reach the current sample target, rendering the device more sensitive. For the same reasoning, the device will be less sensitive when using higher base multipliers. Care should be taken when setting the base multipliers low, as setting them to low, could cause the algorithm not to reach the target. Not reaching the target impact the touch thresholds, as the are derived from the LTA.

7.10 Base Select

The Base Select bit, changes the values of the proximity channel's base value options. This allows for a different range of available options, as illustrated in Table 7.1.

Table 7.1: Base Values of the IQS242.

Base Select		
0	**1**	**Base1:Base0**
200	150	
50	350	
100	500	
250	700	

7.11 Charge Transfer Frequency

The IQS242 has two available for the charge transfer frequency. The default (512kHz) is more sensitive, while the 1MHz option allows for better immunity against false detection in applications where moisture could be present near the sense electrodes. The faster frequency is recommended for better stability and response rate in applications with very thin overlays.

7.12 Streaming mode

There is a streaming bit available that allows for serial data communication on the IQS242. Streaming is done via an I^2C^{TM} compatible 3-wire interface, which consist of a data (SDA), clock (SCL) and ready (RDY) line. The IQS242 can only function as a slave 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 low when it is ready for communication, and it will high when it is doing conversions. The IQS242 will not ack on its address while the RDY line is high (thus while the IQS242 is doing conversions).

7.13 Noise Detect

The IQS242 has advanced 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. 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 electrode and button design principles must be followed.
- ❏ Unintentional coupling of sense electrode 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 electrode may provide significant shielding from undesirable interference.

However, if interference from RF noise sources persist after proper layout, see [2], the IQS242 has a noise detect function which will detect RF noise and block outputs from the device. Different antenna layouts can be used on the RF detect pin (pin 6) and more details can be found in [2].

7.14 Low Power Mode

The IQS242 IC has four power modes specifically designed to reduce current consumption for battery applications. The power modes are implemented around the occurrence of charge cycle every t_{SAMPLE} seconds (refer to Table 7.2). Lower sampling frequencies yield lower power consumption (but decreased response time). During normal operation charge cycles are initiated approximately every 50ms. This is referred to as

Normal Power Mode (NP). The IQS242 by default charges in Boost Power Mode. The timings for all the Power Modes are provided in the table below. While in any power mode the device will zoom to BP whenever a current sample (CS) indicates a possible proximity or touch event. This improves the response time. The device will remain in BP for t_{ZOOM} seconds and then return to the selected power mode. The Zoom function allows reliable detection of events with current samples being produced at the BP rate.

Table 7.2: IQS242 Low Power Mode Timings

Power Mode	t_{SAMPLE} (ms)
t_{BP} (default)	9
t_{NP}	32
t_{LP1}	128
t_{LP2}	1000

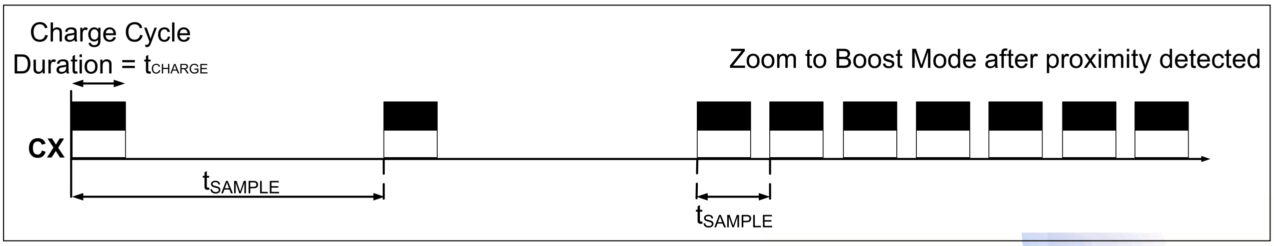


Figure 7.1: LP Modes: Charge cycles.

7.15 UI Select

The IQS242 can opperate as a normal two channel proximity and touch sensor, or it can be set to function as a two channel Dycal device.

7.16 Output Logic Select

The IQS242 can be set to sink or source current in stand-alone mode, by setting the logic output active high or active low. For characterisation data, please refer to Table 11.3.

7.17 ATI Delay

The IQS242 allows an ATI delay option of 0 seconds (immediately) or 10 seconds after the Proximity output is cleared (and the current samples are not within the allowed ATI band)

7.18 ATI Target

The default target counts of the IQS242 are 1000 for both channels. However, for some application, a less sensitive and lower target is acceptable, which will also increase the response rate. Therefore, the ATI Target bit can be set, changing the targets to 500.

8 Charge Transfers

The IQS242 samples in 2 time slots, with one internal C_S capacitor. The charge sequence is shown in Figure 8.1. The IQS242 charges its two channels (CH1 and CH2) independently in the two time slots. In both time slots, the other channel (not charging) will be grounded.

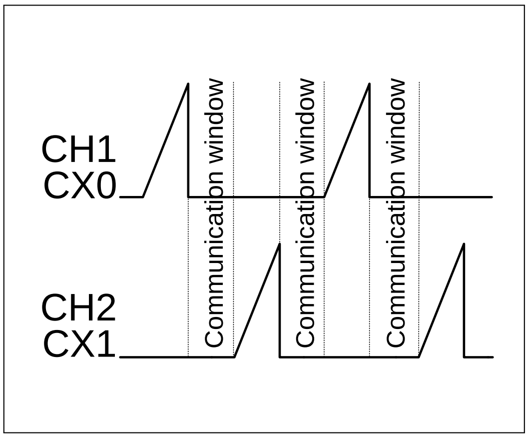


Figure 8.1: Charge Transfer for IQS242.

9 DYCAL

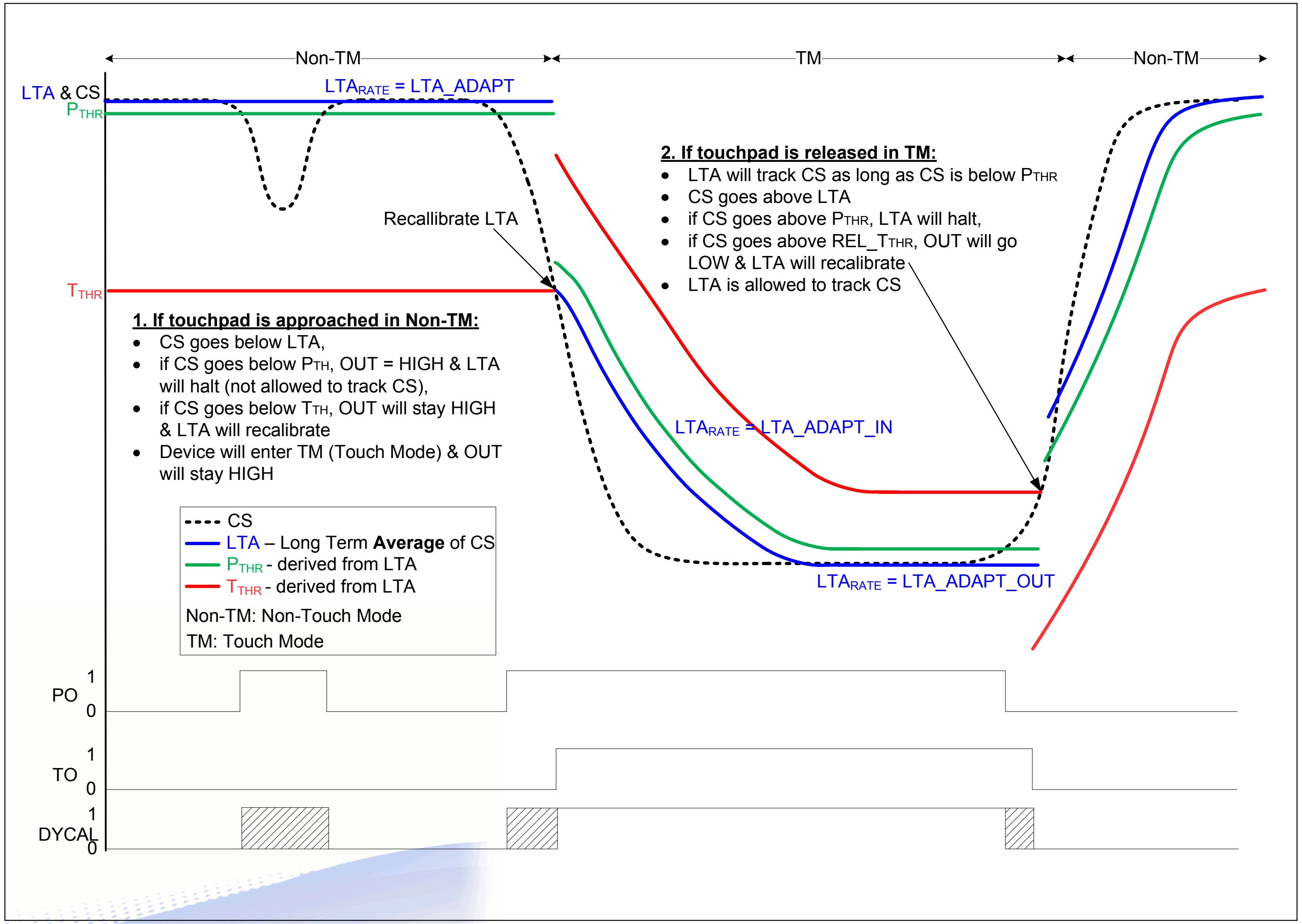


Figure 9.1: DYCAL Overview.

9.1 Operating Principle

Figure 9.1 is a visual representation of the DYCAL™ functionality. The DYCAL output is used to indicate the status of a DYCAL™ event (both a proximity and a touch event). The DYCAL™ functionality is summarised below. More illustrations are given in Appendix B.

Non-Touch Mode

The DYCAL output is activated on the successful detection of a proximity event and will remain activated for the duration of the proximity event, permitting that this event is not longer than the filter halt timings. The LTA will be halted in this time. As soon as a touch condition is detected (CS below T_{THR}), the controller will dynamically re-calibrate its LTA to the halted LTA - T_{THR}. The IC is now in Touch Mode (TM).

Touch Mode

After the re-calibration of the LTA, it will follow the CS and be allowed to track slow varying environmental changes. If the CS were to exceed the LTA by a release threshold (REL_T_{THR}) the touch detection will stop and the DYCAL output will return to its original state.

9.2 Dycal Quick Reference

Table 9.1: Status of IQS242 upon a Proximity Event

Proximity Event					
UI	**Dycal Select**	**PO**	**TO**	**Halt timer**	**LTA**
Normal	N/A	Active	Not Active	Start	Halt
Dycal	Touch	Active	Not Active	Start	Halt
Dycal	Prox	Active	Active	Not Active	Follow CS

Table 9.2: Status of IQS242 upon a Touch Event

Touch Event					
UI	**Dycal Select**	**PO**	**TO**	**Halt timer**	**LTA**
Normal	N/A	Active	Active	Restart	Halt
Dycal	Touch	Active	Active	Not Active	Follow CS
Dycal	Prox	Active	Active	Not Active	Follow CS

10 Automatic Tuning Implementation

ATI is a sophisticated technology implemented in all but the first generation ProxSense® devices that optimises the performance of the sensor in a wide range of applications and environmental conditions refer to application note [7], AZD027 - Automatic Tuning Implementation. ATI makes adjustments through internal reference capacitors to obtain optimum performance. ATI adjusts internal circuitry according to two parameters, the ATI multipliers and the ATI compensation. The ATI multiplier can be viewed as a course adjustment and the ATI compensation as a fine adjustment. The adjustment of the ATI parameters will result in variations in the current sample and sensitivity. Sensitivity can be observed as the change in current sample as the result of a fixed change in sensed capacitance. The ATI parameters have been chosen to provide significant overlap. It may therefore be possible to select various combinations of ATI multiplier and ATI compensation settings to obtain the same current sample. The sensitivity of the various options may however be different for the same current sample.

10.1 Full ATI

The IQS242 implements an ATI algorithm. This algorithm automatically adjusts the ATI parameters to optimise the sensing electrodes' connection to the device. The device will execute the ATI algorithm whenever the device starts-up and when the current samples are not within a predetermined range. While the Automatic ATI algorithm is in progress this condition will be indicated in the streaming data and proximity and touch events cannot be detected. The device will only briefly remain in this condition and it will be entered only when relatively large shifts in the current sample has been detected. The automatic ATI function aims to maintain a constant current sample, regardless of the capacitance of the sense electrode (within the maximum range of the device). The effects of auto-ATI on the application are the following:

- ❏ Automatic adjustment of the device configuration and processing parameters for a wide range of PCB and application designs to maintain an optimal configuration for proximity and touch detection.
- ❏ Automatic tuning of the sense electrode at start-up to optimise the sensitivity of the application.
- ❏ Automatic re-tuning when the device detects changes in the sensing electrodes capacitance to accommodate a large range of changes in the environment of the application that influences the sensing electrodes.
- ❏ Re-tuning only occurs during device operation when a relatively large sensitivity reduction is detected. This is to ensure smooth operation of the device during operation.
- ❏ Re-tuning may temporarily influences the normal functioning of the device, but in most instances the effect will be hardly noticeable.
- ❏ Shortly after the completion of the re-tuning process the sensitivity of Proximity detection may be reduced slightly for a few seconds as internal filters stabilises. Automatic ATI can be implemented so effectively due to:
- ❏ Excellent system signal to noise ratio (SNR).
- ❏ Effective digital signal processing to remove AC and other noise.
- ❏ The very stable core of the devices.

❑ The built in capability to accommodate a large range of sensing electrode capacitances.

10.2 Partial ATI

If the ATI Select bit is set to Partial ATI, the touch threshold for CH2 is the same as for CH1 (see Section 7.1, CH1's touch threshold is now also set in Bank 0) and the first 5 bits of Bank 1, changes to Multiplier bits (both Sensitivity and Compensation).If the ATI bit is not set (default), CH2 has its own touch threshold. Setting the partial ATI bit is useful for production devices (after prototyping has revealed the correct setup) as it decreases the start-up time of the IC, since the full ATI algorithm is not implemented at from a cold-start.

11 Specifications

Absolute Maximum Specifications

The following absolute maximum parameters are specified for the device: Exceeding these maximum specifications may cause damage to the device.

- Operating temperature — −40 °C to +85 °C
- Supply Voltage (VDDHI - GND) — 3.6 V
- Maximum pin voltage — VDDHI + 0.5 V
- Maximum continuous current (for specific Pins) — 2 mA
- Minimum pin voltage — GND - 0.5 V
- Minimum power-on slope — 100 V /s
- ESD protection — ±4 kV
- Moisture Sensitivity Level — MSL 1

Table 11.1: IQS242 General Operating Conditions

Description	Condition	Parameter	MIN	TYP	MAX	Unit
Supply voltage		VDDHI	1.8		3.6	V
Internal regulator output	1.8 ≤ VDDHI ≤ 3.3	VREG	1.62	1.7	1.79	V
Boost operating current	1.8 ≤ VDDHI ≤ 3.3	$I_{IQS242BP}$		148		µA
Normal operating current	1.8 ≤ VDDHI ≤ 3.3	$I_{IQS242NP}$		94		µA
Low power operating current	1.8 ≤ VDDHI ≤ 3.3	$I_{IQS242LP1}$		25		µA
Low power operating current	1.8 ≤ VDDHI ≤ 3.3	$I_{IQS242LP2}$		4		µA

Table 11.2: Start-up and shut-down slope Characteristics

Description	Condition	Parameter	MIN	MAX	Unit
POR	VDDHI Slope ≥ 100 V/s	POR	1.2	1.6	V
BOD		BOD	1.15	1.55	V

Table 11.3: POUT and TOUT Characteristics for each I/O

Symbol	Description	Conditions	I_{SOURCE}	UNIT
VOH	Output High voltage	VDDHI = 3.3V	5	mA
Symbol	**Description**	**Conditions**	I_{SINK}	**UNIT**
VOL	Output Low voltage	VDDHI = 3.3V	10	mA

Table 11.4: Initial Touch Times

Description	Parameter	MIN	MAX	Unit
BP	Report Rate	15	43	ms
NP	Report Rate	42	102	ms
LP1	Report Rate	42	198	ms
LP2	Report Rate	42	1070	ms

Table 11.5: Repetitive Touch Rates

DESCRIPTION	Sample rate	Response Rate	UNIT
All power modes	5ms	> 18	Touches/second
All power modes	9ms	> 12	Touches/second

12 Mechanical Dimensions

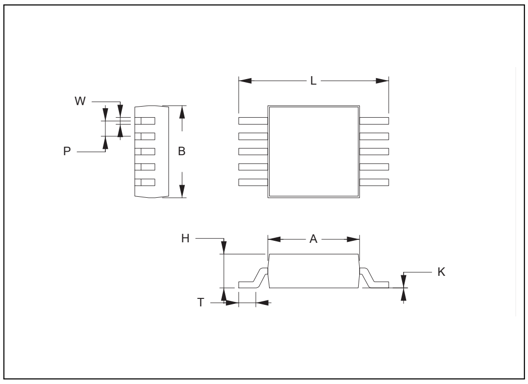


Figure 12.1: MSOP10 Package.

Table 12.1: MSOP10 Package Dimensions.

Dimension	[mm]
A_min	2.90
A_max	3.10
B_min	2.90
B_max	3.10
H_max	1.1
L_min	4.75
L_max	5.05
T_min	0.40
T_max	0.70
Pitch	0.50
W_min	0.17
W_max	0.27

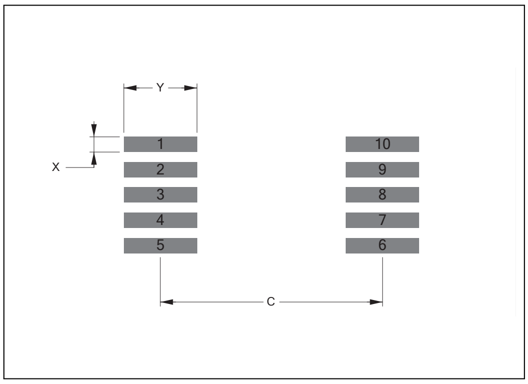


Figure 12.2: MSOP10 Footprint.

Table 12.2: MSOP-10 Footprint Dimensions

Dimension	mm
Pitch	0.50
C	4.40
Y	1.45
X	0.30

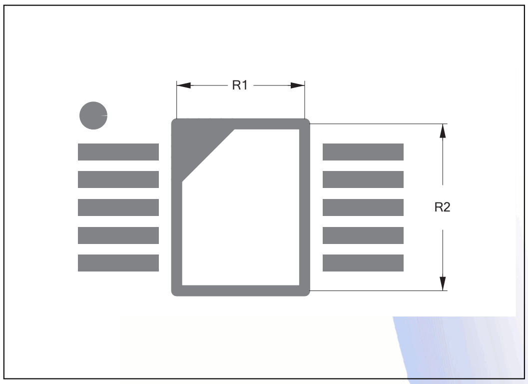
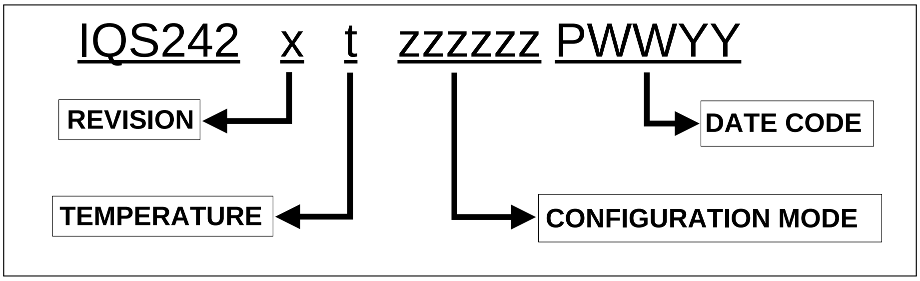


Figure 12.3: MSOP10 Silk Screen.

Table 12.3: MSOP-10 Silk Screen Dimensions

Dimension	mm
R1	2.30
R2	3.00

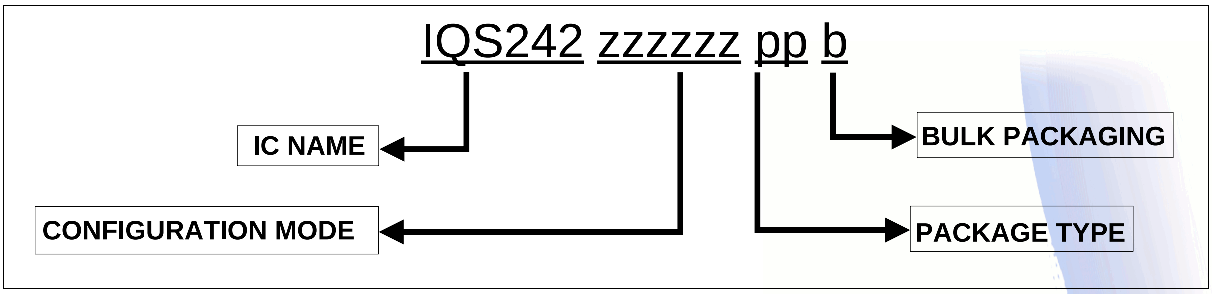
13 Device Marking



REVISION	x	=	IC Revision Number
TEMPERATURE RANGE	t	=	I −40 °C to 85 °C (Industrial)
		=	C 0 °C to 70 °C (Commercial)
IC CONFIGURATION	zzzzzz	=	Configuration (Hexadecimal)
DATE CODE	P	=	Package House
	WW	=	WEEK
	YY	=	YEAR

14 Ordering Information

Orders will be subject to a MOQ (Minimum Order Quantity) of a full reel. Contact the official distributor for sample quantities. A list of the distributors can be found under the "Distributors" section of www.azoteq.com. For large orders, Azoteq can provide pre-configured devices. The Part-number can be generated by using USBProg.exe or the Interactive Part Number generator on the website.



IC NAME	IQS242	=	IQS242
CONFIGURATION	zzzzzz	=	IC Configuration (hexadecimal)
PACKAGE TYPE	MS	=	MSOP-10
BULK PACKAGING	R	=	Reel (4000pcs/reel) - MOQ = 4000pcs

15 Contact Information

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The following patents relate to the device or usage of the device: US 6,249,089 B1, US 6,621,225 B2, US 6,650,066 B2, US 6,952,084 B2, US 6,984,900 B1, US 7,084,526 B2, US 7,084,531 B2, US 7,119,459 B2, US 7,265,494 B2, US 7,291,940 B2, US 7,329,970 B2, US 7,336,037 B2, US 7,443,101 B2, US 7,466,040 B2, US 7,498,749 B2, US 7,528,508 B2, US 7,755,219 B2, US 7,772,781, US 7,781,980 B2, US 7,915,765 B2, EP 1 120 018 B1, EP 1 206 168 B1, EP 1 308 913 B1, EP 1 530 178 B1, ZL 99 8 14357.X, AUS 761094

A Memory Map

00H

	Product Number								R/W
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
	Product Number								
Default	0x1F								R

01H

	Version Number								R/W
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
	Version Number								
Default	0x0B								R

10H

	System Flags								R/W
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
	System Use				**LP**	**ATI Busy**	**ND**	**Zoom**	
Default					0	0	0	0	R

31H

	Proximity Channels								R/W
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
						CH2	**CH1**		
Default						0	0		R

35H

	Touch Channels								R/W
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
						CH2	**CH1**		
Default						0	0		R

36H		Dycal Touch								R/W
	Bit	7	6	5	4	3	2	1	0	
							CH2	CH1		
	Default						0	0		R

37H		Dycal Output								R/W
	Bit	7	6	5	4	3	2	1	0	
							CH2	CH1		
	Default						0	0		R

39H		Filter Halt								R/W
	Bit	7	6	5	4	3	2	1	0	
							CH2	CH1		
	Default						0	0		R

3DH		Channel Number								R/W
	Bit	7	6	5	4	3	2	1	0	
	Default	Current Channel								R

42H		Current Sample (CS)								R/W
	Bit	7	6	5	4	3	2	1	0	
		High Byte								
	Default									R

43H		Current Sample (CS)								R/W
	Bit	7	6	5	4	3	2	1	0	
		Low Byte								
	Default									R

83H

	Long Term Average (LTA)								R/W
Bit	7	6	5	4	3	2	1	0	
	High Byte								
Default									R

84H

	Long Term Average (LTA)								R/W
Bit	7	6	5	4	3	2	1	0	
	Low Byte								
Default									R

C4H

	OTP Bank 0								R/W
Bit	7	6	5	4	3	2	1	0	
	Details in Table 6.1								
Default									R/W

C5H

	OTP Bank 1								R/W
Bit	7	6	5	4	3	2	1	0	
	Details in Table 6.3								
Default									R/W

C6H

	OTP Bank 2								R/W
Bit	7	6	5	4	3	2	1	0	
	Details in Table 6.5								
Default									R/W

C7H

	OTP Bank 3								R/W
Bit	7	6	5	4	3	2	1	0	
	Details in Table 6.6								
Default									R/W

B Dycal^{TM} Illustrations

To view the illustrations in Appendix B, the document requires to be opened with Adobe Reader Version 6 or later. Note that all illustrations are supplementary, and are not required to use with the datasheet.

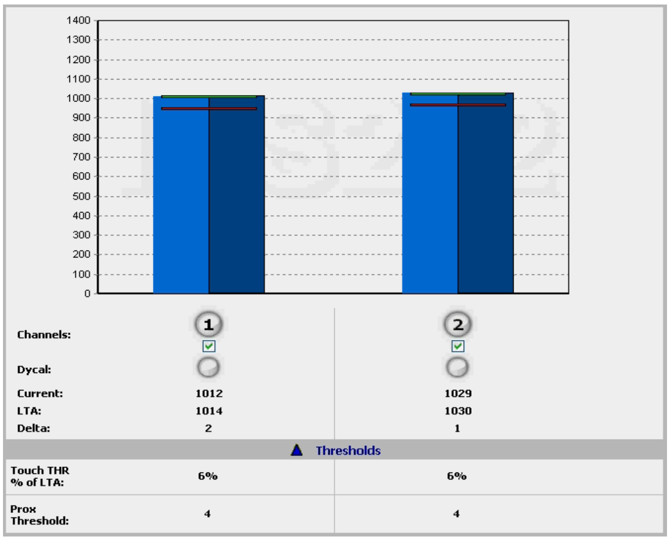

Figure B.1: As the counts falls with the user approaching, the LTA will follow it, until the proximity threshold is exceeded. After exceeding P$_{TH}$, the LTA will halt until the CS exceeds the touch threshold. After the CS exceeds T$_{TH}$, the LTA will once again follow, as touch mode (TM) is entered. The LTA will keep on following the CS until the user retracts far enough from the sense area to exceed P$_{TH}$ again, this time in the other direction. The LTA will once again halt, until the release threshold is exceed where after TM is exited and LTA is recalibrated.

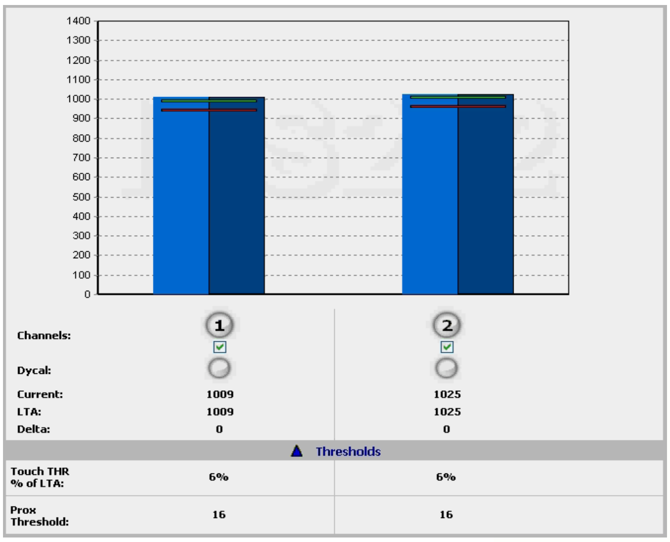

Figure B.2: The Dycal output is activated as soon as the CS falls below P$_{TH}$. Touch mode is not entered, as the CS did not fall below T$_{TH}$. After t$_{HALT}$ elapsed (shortened in the illustration), the LTA will cease to halt, and follow the CS. Once the delta (LTA - CS) is less than P$_{TH}$, both the proximity and Dycal outputs are cleared.

References

[1] *AZD013 - Calculating Rx for improving ESD ratings*. Azoteq, 2008.

[2] *AZD015 - RF Immunity Guidelines*. Azoteq, 2011.

[3] *AZD051 - Electrical Fast Transient Burst Guidelines*. Azoteq, 2011.

[4] *AZD052 - Conducted RF Immunity Guidelines*. Azoteq, 2011.

[5] *AZD008 - Design Guidelines for Touch Pads*. Azoteq, 2011.

[6] *AZD007 - USB Prog Overview*. Azoteq, 2008.

[7] *AZD027 - Auto Tuning Implementation*. Azoteq, 2009.