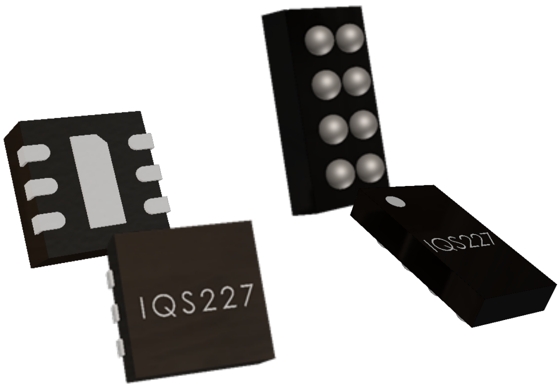
IQS227B/D DATASHEET

Single Channel Capacitive Proximity and Touch Controller

The **IQS227B/D** ProxSense® IC is a fully integrated Self Capacitive sensor with dual outputs (Touch and Proximity outputs).

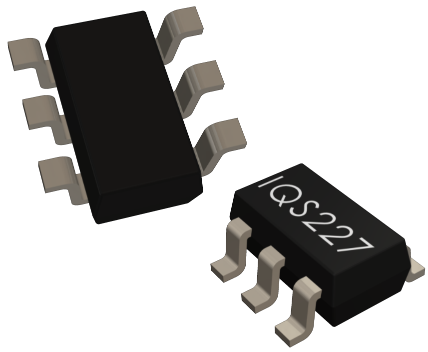
Features

- **A**utomatic **T**uning **I**mplementation (ATI) - Automatic tuning of sense electrode
- Minimum external components
- Data streaming option
- Advanced on-chip digital signal processing
- User selectable (OTP) :
  - 4 Power Modes
  - IO sink / source
  - Time-out for stuck key
  - Output mode (Direct/Latch/Toggle)
  - Proximity and Touch Button sensitivity



Applications

- LCD, Plasma & LED TVs
- GSM cellular telephones - On ear detection / touch keys
- LED flashlights or headlamps
- White goods and appliances
- Office equipment, toys, sanitary ware
- Flameproof, hazardous environment Human Interface Devices
- Proximity detection enables backlighting activation
- Wake-up from standby applications
- Replacement for electromechanical switches
- Find-In-The-Dark (FITD) applications
- Automotive: Door pocket lighting, electric window control
- GUI trigger on Proximity detected



RoHS2
Compliant

Packages
Representation only, not actual markings

Available Options

T_A	Supply Voltage	Low Power Mode	DFN-6	TSOT23-6	WLCSP-8
-40°C to 85°C	1.8 V to 3.6 V	2.5 µA	IQS227B	IQS227B	IQS227B
	2.4 V to 5.5 V	5 µA	IQS227D	IQS227D	-

Contents

List of Abbreviations

ATI	Automatic Tuning Implementation
BP	Boost Power Mode
CS	Counts (Number of Charge Transfers)
C_S	Internal Reference Capacitor
DYCAL™	Dynamic Calibration
EMI	Electromagnetic Interference
ESD	Electro-Static Discharge
FTB/EFT	(Electrical) Fast Transient Bursts
GND	Ground
HC	Halt Charge
LP	Low Power Mode
LTA	Long Term Average
THR	Threshold

1 Overview

1.1 Device

The IQS227B/D is a single channel capacitive proximity and touch controller with an internal voltage regular and reference capacitor (C_S).

The IQS227B/D device has dedicated pin(s) for the connection of sense electrodes (Cx) and output pins for proximity events on **POUT** and touch event on **TOUT**. The output pins can be configured for various output methods including a I^2C data streaming option on **TOUT** and **POUT**.

Device configuration is determined by One Time Programmable (OTP) options. The device can automatically track slow varying environmental changes via various filters and detect noise. It has an Automatic Tuning Implementation (ATI) to tune the device sense electrode(s).

The *charge transfer* method of capacitive sensing is employed on the IQS227B/D. (The Charge Transfer principle is thoroughly described in the application note: *AZD004 - Azoteq Capacitive Sensing*)

1.2 Operation

The analogue circuitry measures the capacitance of a sense electrode attached to the Cx pin through a charge transfer process that is periodically initiated by the digital circuitry. The measuring process is referred to a conversion and consists of the discharging of reference capacitor 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 (CS). The capacitance measurement circuitry makes use of an internal Cs and voltage reference (VREG). The analogue circuitry further provides functionality for:

- Power on reset (POR) detection.
- Reset detection.
- Detection of a watch dog timer (WDT)

1.3 Applicability

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

- Temperature:
  - IQS227B/D: -40°C to 85°C
- Supply voltage (V_{DDHI}):
  - IQS227B: 1.8 V to 3.6 V
  - IQS227D: 2.4 V to 5.5 V

2 Packaging and Pin-Out

The IQS227B is available in a TSOT23-6, DFN-6 or WLCSP-8 package. The IQS227D is available in a DFN-6 or TSOT23-6 package.

2.1 Pin-out TSOT23-6

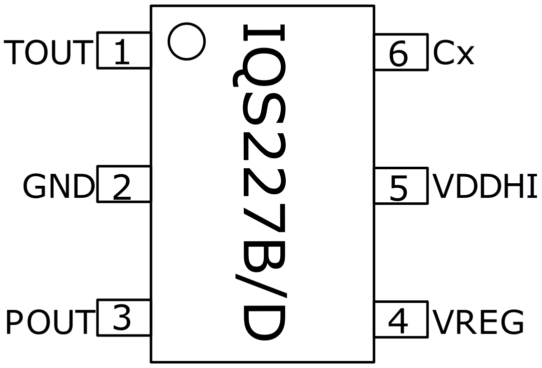


Figure 2.1: IQS227B/D TSOT23-6 Pin-out

Table 2.1: IQS227B/D TSOT23-6 Pin-out Description

Pin	Name	Type	Function
1	TOUT	Digital Output	Touch output
2	GND	Ground	GND Reference
3	POUT	Digital Output	Proximity output
4	VREG	Analogue Output	Internal Regulator Pin (Connect 1µF bypass capacitor)
5	VDDHI	Supply Input	Supply voltage Input
6	Cx	Analogue	Sense Electrode

2.2 Pin-out WLCSP-8

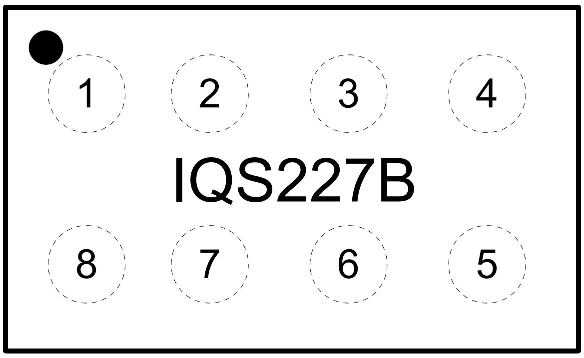


Figure 2.2: IQS227B WLCSP-8 Pin-out

Table 2.2: IQS227B WLCSP-8 Pin-out Description

Pin	Name	Type	Function
1	Cx	Sense electrode	Connect to conductive area intended for sensor
2	TOUT	Digital Output	Touch output
3	VREG	Regulator output	Requires external capacitor
4	VSS	Signal GND	GND Reference
5	INPUT	Digital Input	Floating input during runtime. Recommended: Connect to POUT
6	POUT	Digital Output	Proximity output
7	VDDHI	Supply Input	Supply voltage input
8	PGM	Configuration pin	Connection for OTP programming. Floating input during runtime. Recommended: Connect to TOUT pin. Programming can still be performed using this pin, provided a diode is used. (See AZD026 - Configuration Tools Overview)

2.3 Pin-out DFN-6

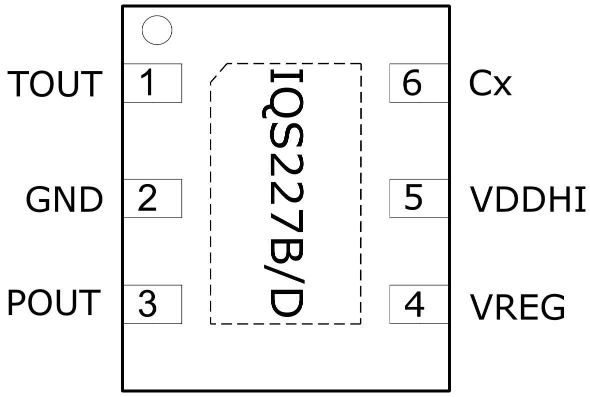


Figure 2.3: IQS227B/D DFN-6 Pin-out

Table 2.3: IQS227B/D DFN-6 Pin-out Description

Pin	Name	Type	Function
1	TOUT	Digital Output	Touch Output
2	GND	Ground	GND Reference
3	POUT	Digital Output	Proximity Output
4	VREG	Analogue Output	Internal Regulator Pin
5	VDDHI	Supply Input	Supply voltage Input
6	Cx	Analogue I/O	Sense Electrode
7	PAD	VSS	Electrically connected to GND

3 Schematic

3.1 TSOT23-6

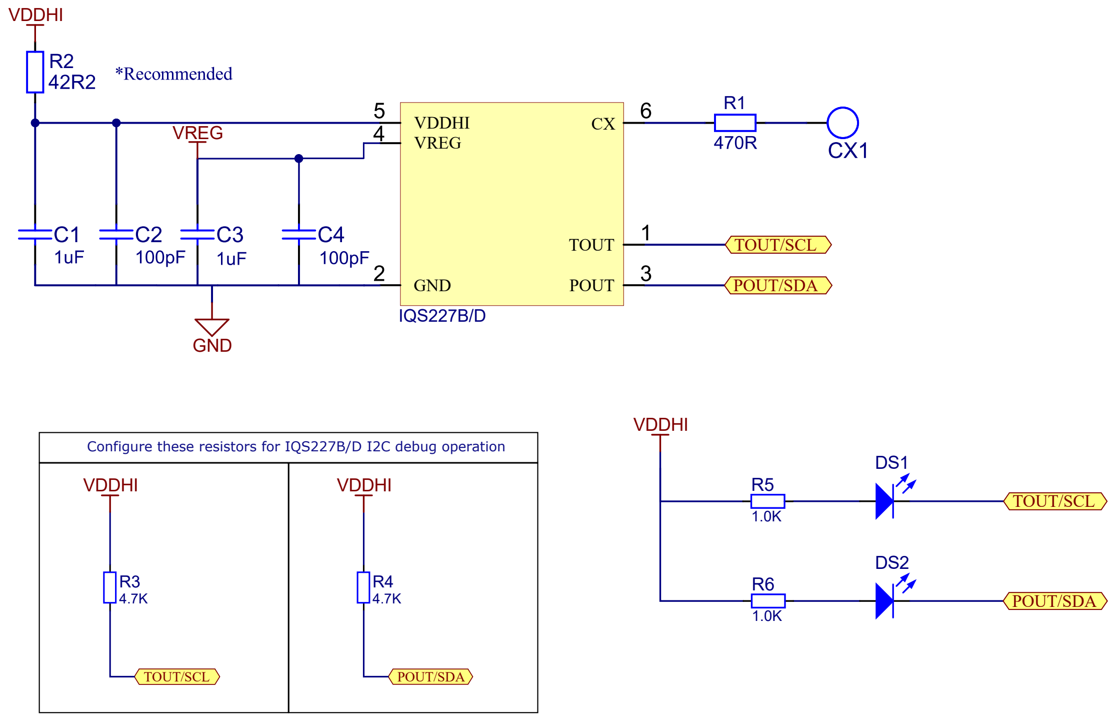


Figure 3.1: Typical application reference schematic of IQS227B/D. 100 pF capacitors are optional for added RF immunity. Place all decoupling capacitors (on VDDHI and VREG) as close to the IC as possible.

3.2 WLCSP-8

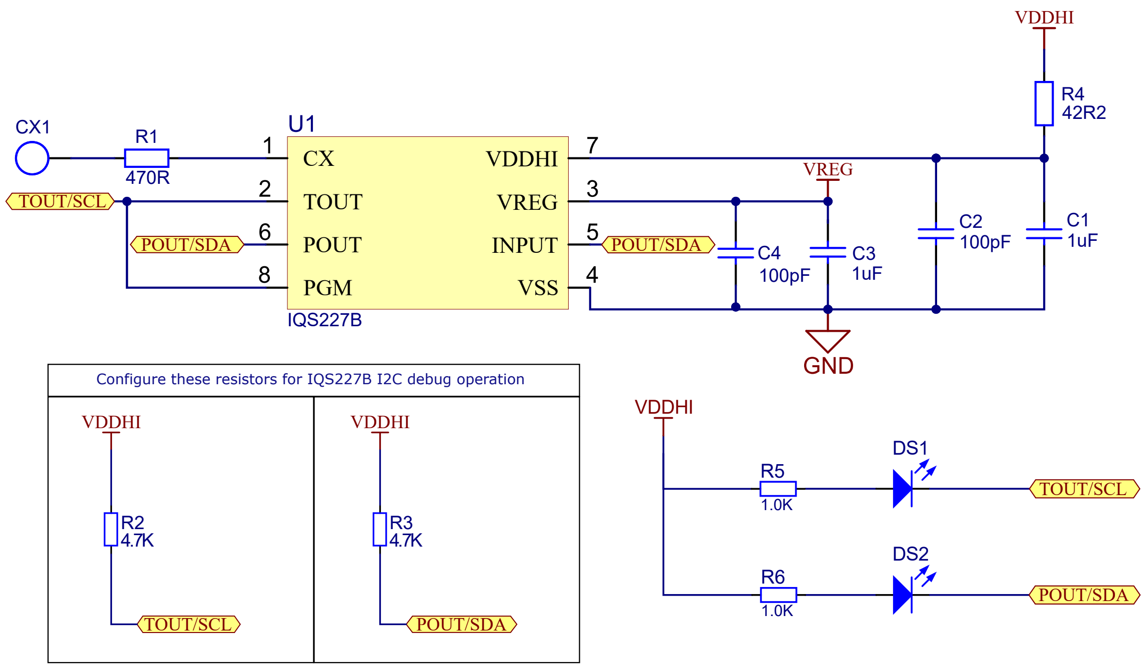


Figure 3.2: Typical application reference schematic of IQS227B WLCSP-8 Package. 100 pF capacitors are optional for added RF immunity. Place all decoupling capacitors (on VDDHI and VREG) as close to the IC as possible.

3.3 DFN-6

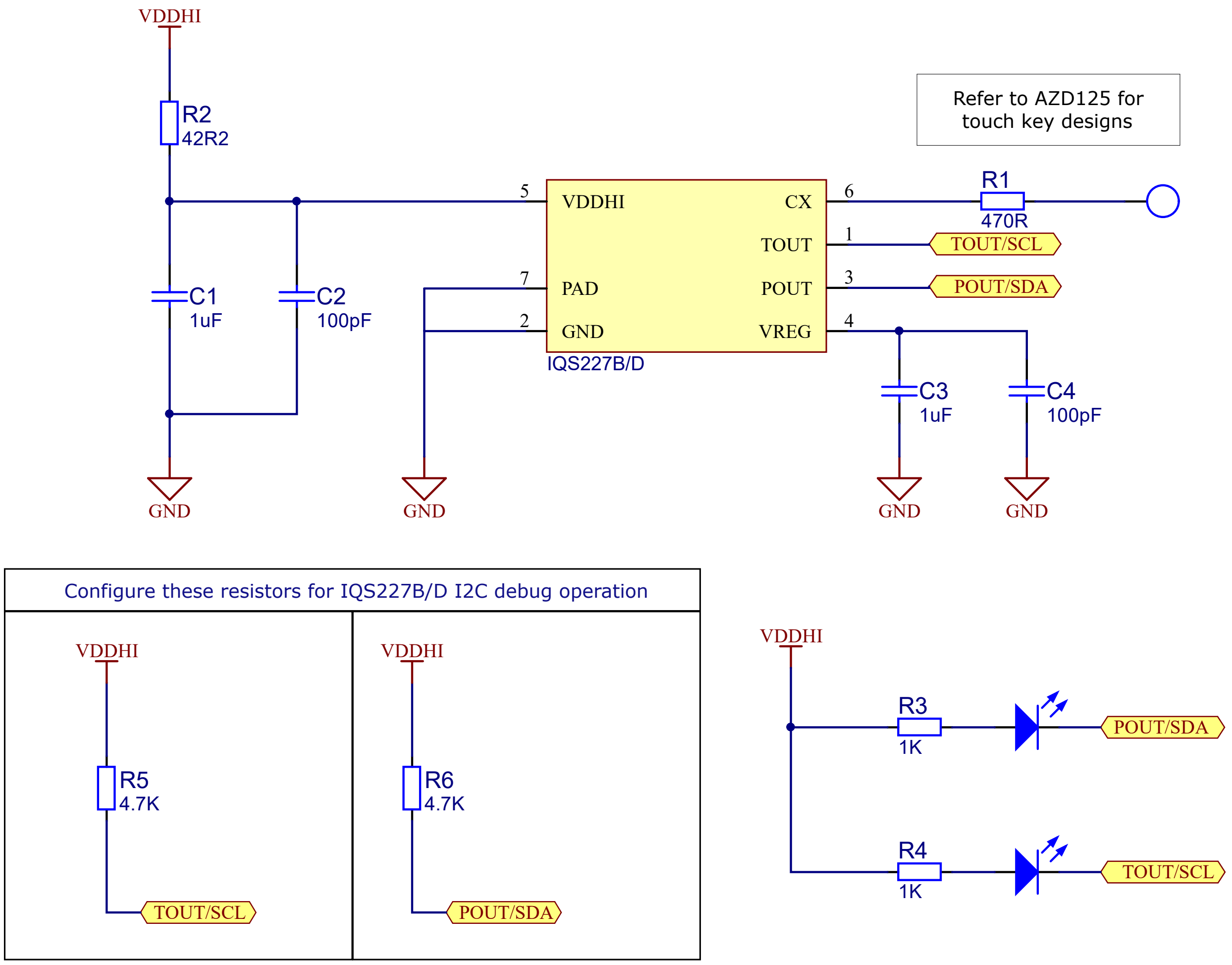


Figure 3.3: Typical application schematic of IQS227B/D. 100 pF capacitors are optional for added RF immunity. Place all decoupling capacitors (on VDDHI and VREG) as close to the IC as possible.

3.4 Additional Information and Recommendations

This section describes additional design considerations that is applicable to all reference schematics found in Section 3.1 to 3.3.

Pins TOUT and POUT can be set as Active High or Active Low[i]. See Section 4.1 for more information.

Where a system level ESD strike is found to cause the IC to go into ESD induced latch-up, it is suggested that the supply current to the IQS227B/D IC is limited by means of a series resistor that could limit the maximum supply current to the IC to <80 mA.

The 1 µF capacitors on VDDHI and VREG are for default power mode. Please see Table 3.2 to select the correct capacitors for low power modes.

The 470 Ω series resistor on the Cx pin is added for ESD protection.

[i]With the Active High setting, a pull-up resistor is not required. Adding a pull-up resistor in Active High mode negatively impacts the current usage.

3.5 Recommended Capacitor Values

The 1 µF VREG capacitor(C3 in Figure 3.1, 3.2 and 3.3) value is chosen to ensure VREG does not fall the maximum remains above the maximum BOD specification stated in Table 9.2 (IQS227B) and 9.4 (IQS227D). The combination of the 1 µF VREG capacitor and the 1 µF VDDHI capacitor is chosen to prevent a potential ESD issue. Recommended values to prevent this is shown in Table 3.1.

Table 3.1: VDDHI and VREG capacitor size recommendation to prevent ESD issues with typical hardware combinations

Low Power Scan	8ms(default) - 32ms	64ms	128ms	160ms
Capacitor recommendation	C1 = 1 µF C3 = 1 µF	C1 = 4.7 µF C3 = 2.2 µF	C1 = 4.7 µF C3 = 2.2 µF	C1 = 4.7 µF C3 = 2.2 µF

3.6 Exception to recommended capacitor values

In applications where the VDDHI source has high internal resistance or a high resistance path, it will be required to ensure C3 > C1 to prevent a VDDHI BOD after the IC sleep cycle (see Table 9.2 and 9.4).

Table 3.2: Capacitor Values for VDDHI and VREG under certain supply voltage condition

Low Power Scan	8ms(default) - 32ms	64ms	128ms	160ms
Capacitor recommendation	C1 = 1 µF C3 = 1 µF	C1 = 2.2 µF C3 = 4.7 µF	C1 = 4.7 µF C3 = 10 µF	C1 = 4.7 µF C3 = 10 µF

4 User Configurable Options

The IQS227B/D provides One Time Programmable (OTP) user options (each option can be modified only once). The device is fully functional in the default 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 the values of external components chosen. Several standard device configurations are available. Azoteq can supply pre-configured devices for large quantities.

4.1 Configuring of Devices

Azoteq offers a Configuration Tool (CT210) and accompanying software (USBProg2.exe) that can be used to program the OTP user options for prototyping purposes.

Alternative programming solutions for the IQS227B/D also exist. For further enquiries regarding this, please contact Azoteq at ProxSenseSupport@azoteq.com or the local distributor.

Tables 4.1 to 4.3 all represent a hexadecimal byte in the IC configuration segment of the ordering number. As example, Table 4.1 corresponds to the last two numeric digits. These digits are shown in bold text in the caption of the table. The ordering numbers and information are explained in Section 10.1.

*Table 4.1: User Selectable Configuration Options: Bank 0 (0xC4H) – IQS227(B/D)000000**00**DNR*

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
T_{Func}	P_{Func}	LOGIC	T_{THR2}	T_{THR1}	T_{THR0}	P_{THR1}	P_{THR0}

Bit 7 **T_{Func}**: Touch Function — Section 6.3
0 = Normal
1 = Toggle

Bit 6 **P_{Func}**: Proximity Function — Section 6.3
0 = Normal
1 = Latch

Bit 5 **LOGIC**: Output logic select (Only when STREAMING mode is disabled) — Section 6.2
0 = Active low (Open drain configuration - pull-up resistor required)
1 = Active High (Push-pull configuration - no pull-up resistor required)

Bit 4-2 **T_{THR}**: Touch Threshold Selections[i] — Section 6.5
000 = 72/256
001 = 8/256
010 = 24/256
011 = 48/256
100 = 96/256
101 = 128/256
110 = 160/256
111 = 192/256

Bit 1-0 **P_{THR}**: Proximity Threshold Selections[i] — Section 6.4
00 = 4
01 = 2
10 = 8
11 = 16

[i] Refer to Section 11.1 for additional design considerations.

When Full ATI is selected in Bank 2 (Bit 2 in Table 4.3), the settings for bank 1 are those shown in Table 4.2.

Table 4.2: User Selectable Configuration Options: Bank 1 Full ATI (0xC5H) – IQS227(B/D)00000000DNR

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
t_{HALT1}	t_{HALT0}	~	~	~	$BASE_2$	$BASE_1$	$BASE_0$

Bit 7-6 **t_{HALT}**: Halt times — Section 6.11
00 = 20 seconds
01 = 40 seconds
10 = Never
11 = Always (Prox on 40s)

Bit 5-3 **Reserved**

Bit 2-0 **BASE**: Base Value — Section 6.7
000 = 200
001 = 50
010 = 75
011 = 100
100 = 150
101 = 250
110 = 300
111 = 500

Table 4.3: User Selectable Configuration Options: Bank 2 (0xC6H) – IQS227(B/D)00000000DNR

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
STREAM	TRANS	COMMS	~	TARGET	~	LP_1	LP_0

Bit 7 **STREAM**: Streaming Method — Section 7.1
0 = 1-wire
1 = 2-wire (I^2C)

Bit 6 **TRANS**: Charge Transfer Frequency — Section 6.10
0 = 512 kHz
1 = 250 kHz

Bit 5 **COMMS**: Streaming — Section 7
0 = Disabled
1 = Enabled

Bit 4 **Reserved** - Set 0

Bit 3 **TARGET**: ATI Target Counts — Section 6.9
0 = 1024
1 = 512

Bit 2 **ATI**: ATI Selection — Section 8
0 = Full
1 = Partial (Not recommended - Contact Azoteq®)

Bit 1-0 **LP**: Low Power Modes — Section 6.6
00 = BP, 9 ms
01 = NP, 128 ms
10 = LP1, 256 ms
11 = LP2, 512 ms (Not recommended, refer to Table 3.1 and 3.2)

5 Measuring Capacitance Using the *Charge Transfer* Method

The charge transfer method of capacitive sensing is employed on the IQS227B/D. (The charge transfer principle is thoroughly described in the application note: *AZD004 - Azoteq Capacitive Sensing*).

A charge cycle is used to take a measurement of the capacitance of the sense electrode (connected to Cx) relative to ground. It consists of a series of pulses charging Cx and discharging Cx to the reference capacitor, at the charge transfer frequency (f_{Cx} - refer to Section 9.2 and 9.3). The number of the pulses required to reach a trip voltage on the reference capacitor is referred to as Count Value (CS) which is the instantaneous capacitive measurement. The Counts (CS) are used to determine if either a physical contact or proximity event occurred (refer to Section 6.11.1), based on the change in Counts (CS) detected. The typical values of CS, without a touch or proximity condition range between 650 and 1150 Counts, although higher and lower counts can be used based on the application requirements. With counts larger than +/-1150 the gain of the system may become too high causing unsteady operation.

The IQS227B/D schedules a charge cycle every t_{SAMPLE} seconds to ensure regular samples for the processing of results. The duration of the charge cycle is defined as t_{CHARGE}(refer to Section 6.6), and varies according to the counts required to reach the trip voltage. Following the charge cycle other activities such as data streaming is completed (if in streaming mode), before the next charge cycle is initiated.

Please note: Attaching a probe to the Cx pin will increase the capacitance of the sense plate and therefore Cs. This may have an immediate influence on the counts (decrease t_{CHARGE}) and cause a proximity or touch event.

After t_{HALT} seconds the system will adjust to accommodate for this change. If the total load on Cx, with the probe attached is still lower than the maximum Cx load the system will continue to function normally after t_{HALT} seconds with the probe attached.

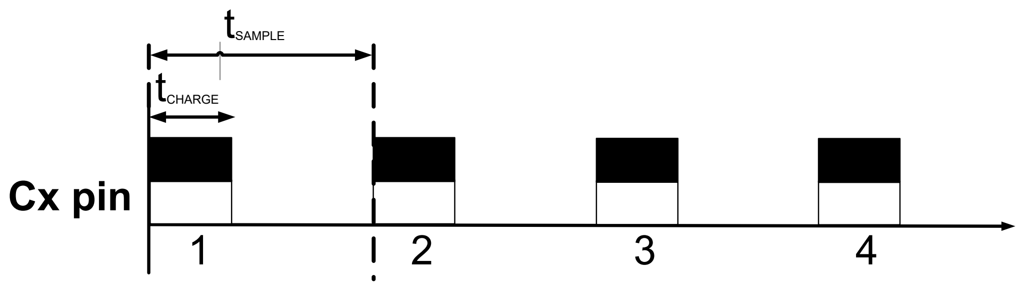


Figure 5.1: Charge cycles as can be seen on Cx.

6 Descriptions of User Options

This section describes the individual user programmable options of the IQS227B/D in more detail.

User programmable options are programmed to One Time Programmable (OTP) fuse registers (refer to Section 4).

Note:

- HIGH=Logical '1' and LOW=Logical '0'.
- The following sections are explained with POUT and TOUT taken as 'Active LOW'.
- The default is always where bits are set to 0.

Refer to Section 9.4 for the sourcing and sinking capabilities POUT and TOUT. These pins are sourced from VDDHI and will be turned HIGH (when active high) for a minimum time of t_{HIGH}, and LOW for a minimum time of t_{LOW} (when active low).

6.1 Proximity / Touch Sensor

The IQS227B/D provides a Proximity output on POUT and a Touch output on TOUT, and does not need to be configured.

6.2 Logic select for outputs

The logic used by the device can be selected as active HIGH or active LOW. The output pins, POUT and TOUT, will function based on this selection. The I/O's are push-pull in both directions and does not require a pull-up resistor. When configured as Active High, the I/O's will remain high at POR until ATI has been completed. ATI times will vary based on the capacitive load on the sensor, but typically do not exceed 500 ms.

Configuration: *Bank 0* Bit 5

LOGIC: Output Logic Select	
Bit	**Selection**
0	Active Low
1	Active High

6.3 Output Pin Function

Various options for the function of the output pin(s) are available. These are selected as follows:

Configuration: *Bank 0* Bit 7-6

FUNC1:FUNC0 OUTPUT Pins' functions	
Bit	**Selection**
00	POUT active, TOUT active
01	POUT latch, TOUT active
10	POUT active, TOUT toggle
11	POUT latch, TOUT toggle

6.3.1 Output function: Active

With a Proximity or Touch event, the output pin will change to LOW and stay LOW for as long as the event remains (see Figure 6.1). Also refer to the use of t_{HALT} Section 6.11.1 that may cause the termination of the event.

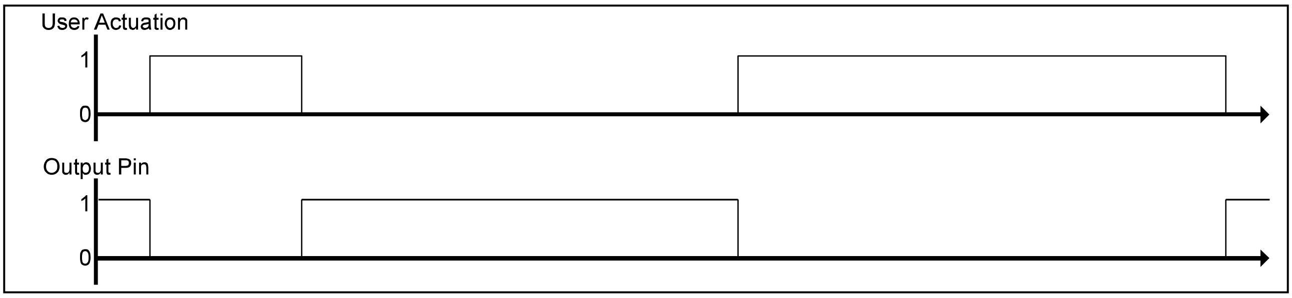


Figure 6.1: Active Mode Output Configuration

6.3.2 Output function: Latch (for t_{LATCH})

With a Proximity or Touch event, the output pin will latch LOW for t_{LATCH} seconds (4 seconds). When the event terminates prior to t_{LATCH} the output pin will remain LOW. When the event remains active longer than t_{LATCH} the output pin will remain LOW as long as the event remains active (see Figure 6.2) When a subsequent event is made before the latch time (4 seconds) has passed, the timer will reset and the output will remain low for another duration of t_{LATCH} seconds (4 seconds). For more details see Figure 6.2.

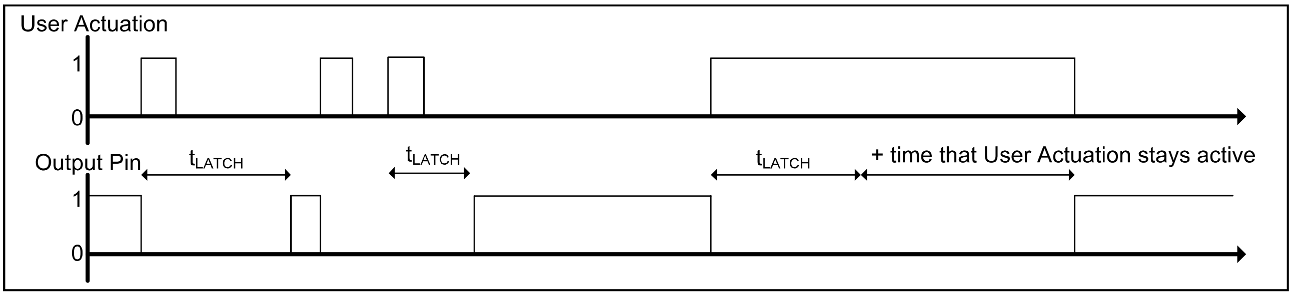


Figure 6.2: Latch Mode Output Configuration

6.3.3 Output function: Toggle

The output pin will toggle with every Proximity or Touch event occurring. Thus, when an event occurs and the output is LOW the output will become HIGH and when the output is HIGH the output will become LOW (see Figure 6.3)

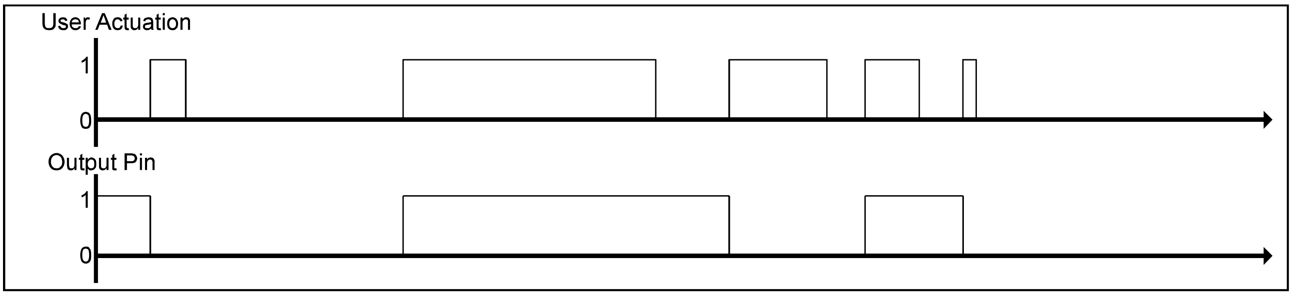


Figure 6.3: Toggle Mode Output Configuration

6.4 Proximity Threshold

The IQS227B/D has 4 proximity threshold settings[i]. 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 Counts (CS) and the LTA (Long Term Average). The threshold is expressed in terms of counts; the same as CS (refer to Section 5). A proximity event is identified when for at least 6 consecutive samples the following equation holds:

$$P_{\text{THR}} =< LTA - CS \quad (1)$$

Where LTA is the Long Term Average (refer to Section 6.11.1)

Configuration: *Bank 0* Bit 1-0

P_{THR1}:P_{THR0} Proximity Threshold	
Bit	**Selection**
00	4
01	2 (Most sensitive)
10	8
11	16 (Least sensitive)

6.5 Touch Threshold

The IQS227B/D has 8 touch threshold settings[i]. 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:

$$T_{\text{THR}} = \frac{x}{256} * LTA \quad (2)$$

The touch event is triggered based on T_{TH}, Counts (CS) and LTA. A touch event is identified when for at least 3 consecutive samples the following equation holds:

$$T_{\text{THR}} =< LTA - CS \quad (3)$$

With lower average counts (therefore lower LTA) values the touch threshold will be lower and vice versa.

[i] Refer to Section 11.1 for additional design considerations.

Configuration: *Bank 0* Bit 4-2

T_{THR2}:T_{THR0}: Touch Thresholds	
Bit	**Selection**
000	72/256
001	8/256 (Most sensitive)
010	24/256
011	48/256
100	96/256
101	128/256
110	160/256
111	192/256 (Least sensitive)

6.6 Power Modes

The IQS227B/D has four power modes specifically designed to reduce current consumption for battery applications. The power modes are basically implemented around the occurrence of charge cycle every t_{SAMPLE} seconds (refer to Table 4.3). The fewer charge transfer cycles that need to occur per second the lower the power consumption (but decreased response time). During Boost Power Mode (BP), charge cycles are initiated approximately every 9 ms. While in any power mode the device will zoom to BP whenever an existing count sample (CS) indicates a possible proximity or touch event. 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 counts being produced at the BP rate.

Configuration: *Bank 2* Bit 1-0

LP : Power Mode Selection	
Bit	**Selection**
00	9 ms (Boost Power Mode)
01	128 ms (Normal Power Mode)
10	256 ms (Low Power Mode 1)
11	512 ms (Low Power Mode 2) Not recommended, refer to Table 3.1 and 3.2

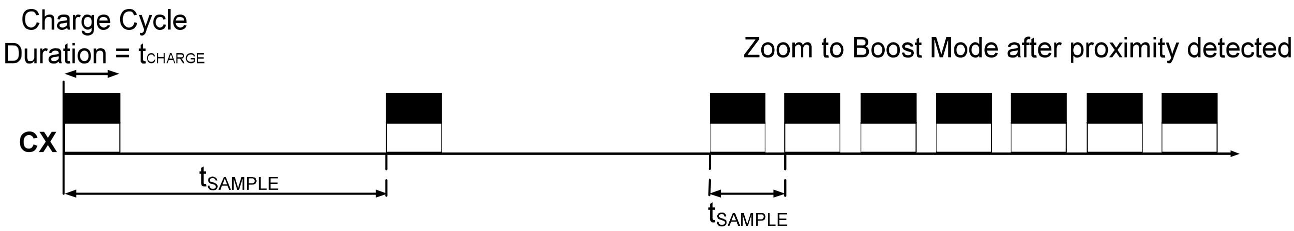


Figure 6.4: Active Mode Output Configuration

6.7 Base Values

The sensitivity of the IQS227B/D can be changed by adjusting the target and base values of the ATI algorithm, and as a result changing the compensation required to reach the set target. See Section 4.1 for the OTP selectable options of BASE (Table 4.2).

$$sensitivity = \frac{TARGET}{BASE} \quad (4)$$

Configuration: *Bank 1* Bit 2-0

BASE : Base Value Select	
Bit	**Selection**
000	200
001	50 (Not Recommended - Contact Azoteq®)
010	75
011	100
100	150
101	250
110	300
111	500

6.8 Multipliers

When using partial ATI, the base value is set up using the multipliers. Compensation will still be added automatically to reach the target.

6.9 ATI Target Counts

The target of the ATI algorithm can be adjusted between 1024 (default) and 512 counts. When less sensitivity is required, the lower counts will also increase response rate. See Section 4.1 for the OTP selectable options of TARGET (Table 4.3).

Configuration: *Bank 2* Bit 3

TARGET : ATI Target Counts	
Bit	**Selection**
0	1024
1	512

6.10 Charge Transfer

The charge transfer frequency of the IQS227B/D is adjustable. Refer to application note *AZD102 - Series resistance limit of self capacitance charge transfers*. Two options are available:

Configuration: *Bank 2* Bit 6

TRANS : Charge Transfer Frequency	
Bit	**Selection**
0	512 kHz
1	250 kHz

6.11 Filters used by the IQS227B/D

The IQS227B/D devices employ various signal processing functions that includes the execution of various filters as described below.

6.11.1 Long Term Average (LTA)

Capacitive touch devices detect changes in capacitance that are not always related to the intended proximity or touch of a human. This is a result of changes in the environment of the sense plate and other factors. These changes need to be compensated for in various manners in order to reliably detect touch events and especially to detect proximity events. One mechanism the IQS227B/D employs is the use of a Long Term Averaging filter (IIR type filter) which tracks slow changes in the environment (expressed as changes in the counts). The result of this filter is a Long Term Average (LTA) value that forms a dynamic reference used for various functions such as identification of proximity and touch events.

The LTA is calculated from the counts (CS). The filter only executes while no proximity or touch event is detected to ensure compensation only for environmental changes. However, there may be instances where sudden changes in the environment or changes in the environment while a proximity or touch event has been detected cause the counts to drift away from the LTA. To compensate for these situations a Halt Timer (t_{HALT}) has been defined. The Halt Timer is started when a proximity or touch event occurs and when it expires the LTA filter is recalibrated. Recalibration causes LTA $<$ CS, thus the disappearance of proximity or touch events (refer to Sections 6.4 and 6.5). The designer needs to select a Halt Timer value to best accommodate the required application.

Configuration: *Bank 1* Bit 7-6

t_{HALT1}:t_{HALT0} OUTPUT Pins' functions	
Bit	**Selection**
00	20 seconds
01	40 seconds
10	NEVER
11	ALWAYS (Proximity on 40 seconds)

Notes:

- The "NEVER" option indicates that the execution of the filters will never be halted.
- With the 'ALWAYS' option and the detection of a proximity event the execution of the filter will be halted for only 40 seconds and with the detection of a touch event the execution of the filter will be halted as long as the touch condition applies.

Refer to Application note *AZD004 - Azoteq Capacitive Sensing* for detail regarding the execution of the LTA filter.

6.11.2 IIR Raw Data filter

The extreme sensitivity of the IQS227B/D makes it susceptible to external noise sources. This causes a decreased signal-to-noise (S/N) ratio, which could potentially cause false event detections. Noise can also couple into the device as a result of poor PCB, sense electrode design and other factors influencing capacitive sensing devices. In order to compensate for noise the IQS227B/D uses an IIR filter on the raw data to minimize result of noise in the counts. This filter is implemented on all the IQS227B/D devices, and cannot be disabled.

7 Data Streaming Mode

The IQS227B/D has the capability to stream data to an MCU. This provides the designer with the capability to obtain the parameters within the device in order to aid design into applications. Data streaming may further be used by an MCU to control events or further process results obtained from the IQS227B/D devices. Data streaming is performed through I^2C communication (SDA on POUT, SCL on TOUT). Data Streaming can be enabled as indicated below:

Configuration: *Bank 2* Bit 7

COMMS: Data Streaming	
Bit	**Selection**
0	Disabled
1	Enabled

Configuration: *Bank 2* Bit 5

STREAMING: Data Streaming Mode	
Bit	**Selection**
0	1-wire
1	2-wire (I^2C)

Data streaming is initiated by the IQS227B/D. When data streaming is enabled, data is sent following each charge.

7.1 I^2C

The IQS227B/D also allow for I^2Cstreaming for debugging. Data Streaming can be changed to I^2C as shown below:

Configuration: *Bank 2* Bit 7

STREAMING: Data Streaming Mode	
Bit	**Selection**
0	1-wire
1	2-wire (I^2C)

The Memory Map for the IQS227B/D can be found in Appendix A. The IQS227B/D can communicate on an I^2C compatible bus structure. Note that 4.7 kΩ pull-up resistors should be placed on SDA and SCL. The Control byte indicates the 7-bit device address (0x44H) and the Read/Write indicator bit.

8 Automatic Tuning Implementation (ATI)

ATI is sophisticated technology implemented in the latest generation ProxSense® devices that optimises the performance of the sensor in a wide range of applications and environmental conditions (refer to application note *AZD004*).

ATI makes adjustments through external reference capacitors unnecessary (as required by most other solutions) to obtain optimum performance.

ATI adjusts internal circuitry according to two parameters, the ATI multiplier 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 counts 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 count value. The sensitivity of the various options may however be different for the same count value.

8.1 Automatic ATI

The IQS227B/D implements an automatic 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 counts 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 counts has been detected. The automatic ATI function aims to maintain a constant count value, 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 electrode.
- 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 influence 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 a 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.
- Built in capability to accommodate a large range of sensing electrode capacitances.

9 Electrical Specifications

9.1 Absolute Maximum Specifications

Exceeding these maximum specifications may cause damage to the device

Operating temperature		-40°C to 85°C
Supply Voltage (V_{DDHI}-V_{SS}):	IQS227B IQS227D	3.6V 5.5V
Maximum pin Voltage (T_{OUT}, P_{OUT})		V_{DDHI} + 0.3V
Minimum pin voltage (V_{DDHI}, V_{REG}, T_{OUT}, P_{OUT}, Cx)		V_{SS} - 0.3V
Minimum power-on slope		100V/s
ESD protection (V_{DDHI}, V_{REG}, V_{SS}, T_{OUT}, P_{OUT}, Cx)		8kV

9.2 IQS227B - General Characteristics

IQS227B devices are rated for supply voltages between 1.8 V and 3.6 V.

Table 9.1: IQS227B General Operating Conditions

Description	Conditions	Parameter	Min	Typ	Max	Unit
Supply voltage		V_{DDHI}	1.8	~	3.6	V
Internal regulator output	$1.8 \leq V_{DDHI} \leq 3.6$	V_{REG}	1.64	~	1.75	V
Boost operating current	$1.8 \leq V_{DDHI} \leq 3.6$	$I_{IQS227B\_BP}$	~	128	~	μA
Normal operating current	$1.8 \leq V_{DDHI} \leq 3.6$	$I_{IQS227B\_NP}$	~	6	~	μA
Low Power 1 operating current	$1.8 \leq V_{DDHI} \leq 3.6$	$I_{IQS227B\_LP1}$	~	3.5	~	μA
Low Power 2 operating current	$1.8 \leq V_{DDHI} \leq 3.6$	$I_{IQS227B\_LP2}$	~	<2.5	~	μA
C_x pin capacitance	$1.8 \leq V_{DDHI} \leq 3.6$	C_{X_Load}	~	~	120	pF
Charge transfer frequency range	$1.8 \leq V_{DDHI} \leq 3.6$	f_{Cx} = 512/250	-8%	f_{Cx}	+8%	kHz

Charge Transfer Timings for low power modes are found in section 6.6.

Table 9.2: IQS227B Start-up and shut-down slope Characteristics

Description	Parameter	Min	Max	Unit
Reset release voltage on V_{DDHI} rising edge	V_{DDHI} Reset Rising Edge (POR)	~	1.7	V
Reset trigger voltage on V_{DDHI} falling edge	V_{DDHI} Reset Falling Edge (BOD)	0.3	~	V
Reset release voltage on V_{REG} rising edge	V_{REG} Reset Rising Edge (POR)	~	1.58	V
Reset trigger voltage on V_{REG} falling edge	V_{REG} Reset Falling Edge (BOD)	0.3	~	V

9.3 IQS227D - General Characteristics

IQS227D devices are rated for supply voltages between 2.4 V and 5.5 V.

Table 9.3: IQS227D General Operating Conditions

Description	Conditions	Parameter	Min	Typ	Max	Unit
Supply voltage		V_{DDHI}	2.4	~	5.5	V
Internal regulator output	$2.4 \leq V_{DDHI} \leq 5.5$	V_{REG}	1.98	~	2.08	V
Boost operating current	$2.4 \leq V_{DDHI} \leq 5.5$	$I_{IQS227D\_BP}$	~	101	~	µA
Normal operating current	$2.4 \leq V_{DDHI} \leq 5.5$	$I_{IQS227D\_NP}$	~	6	~	µA
Low Power 1 operating current	$2.4 \leq V_{DDHI} \leq 5.5$	$I_{IQS227D\_LP1}$	~	4.5	~	µA
Low Power 2 operating current	$2.4 \leq V_{DDHI} \leq 5.5$	$I_{IQS227D\_LP2}$	~	<3.2	~	µA
C_x pin capacitance	$2.4 \leq V_{DDHI} \leq 5.5$	C_{X_Load}	~	~	120	pF
Charge transfer frequency range	$2.4 \leq V_{DDHI} \leq 5.5$	f_{Cx} = 512/250	-8%	f_{Cx}	+8%	kHz

Charge Transfer Timings for low power modes are found in section 6.6.

Table 9.4: Start-up and shut-down slope Characteristics

Description	Parameter	Min	Max	Unit
Reset release voltage on V_{DDHI} rising edge	V_{DDHI} Reset Rising Edge (POR)	~	2.1	V
Reset trigger voltage on V_{DDHI} falling edge	V_{DDHI} Reset Falling Edge (BOD)	0.3	~	V
Reset release voltage on V_{REG} rising edge	V_{REG} Reset Rising Edge (POR)	~	1.8	V
Reset trigger voltage on V_{REG} falling edge	V_{REG} Reset Falling Edge (BOD)	0.3	~	V

9.4 IQS227B/D Output Characteristics

Table 9.5: Digital I/O Characteristics

Parameter		Test Conditions	Min	Typ	Max	Unit
V_{OL}	TOUT and POUT Output low voltage	I_{sink} = 10 mA	~	~	0.3	V
V_{OH}	Output high voltage	I_{source} = 5 mA	VDD – 0.3	~	~	V
V_{IL}	Input low voltage		~	~	0.3 × VDD	V
V_{IH}	Input high voltage		0.7 × VDD	~	~	V

9.5 Packaging Information

9.5.1 TSOT23-6

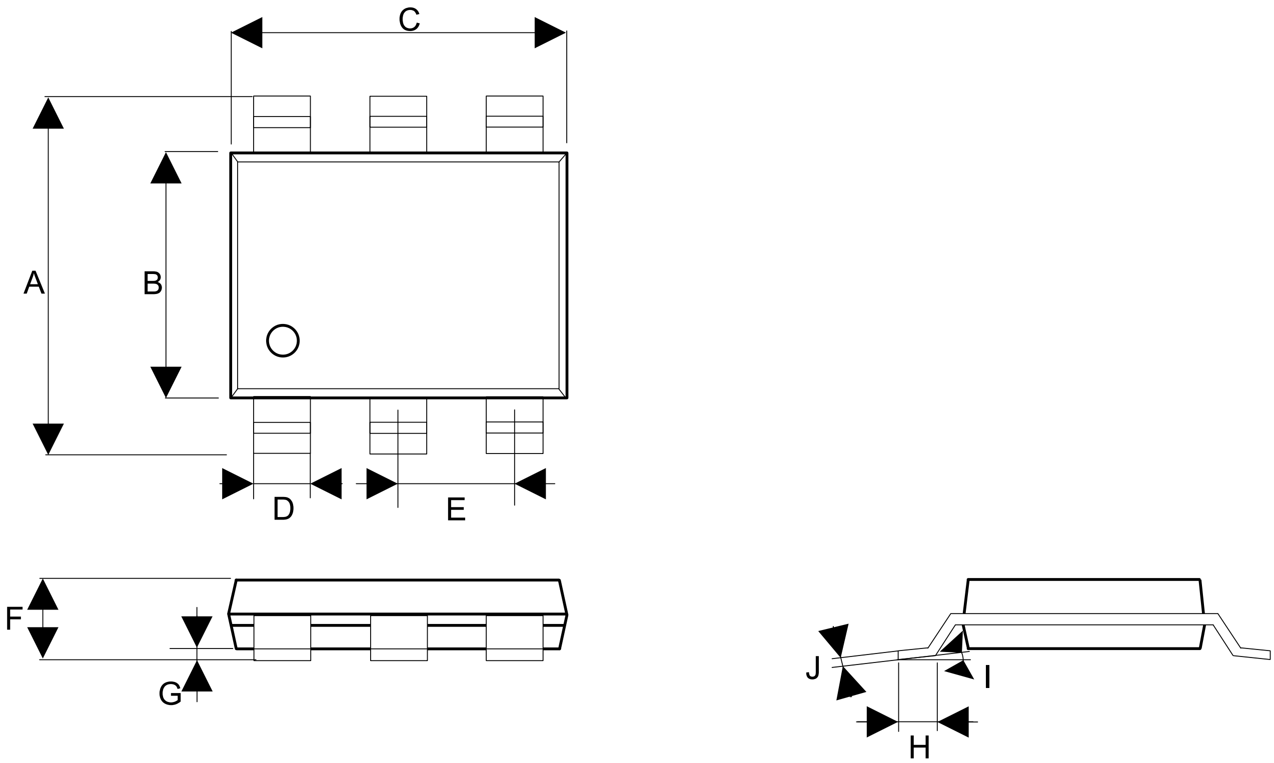


Figure 9.1: IQS227B/D TSOT23-6 Packaging

Table 9.6: IQS227B/D TSOT23-6 Dimensions

Dimension	Min (mm)	Max (mm)
A	2.60	3.00
B	1.50	1.70
C	2.80	3.00
D	0.30	0.50
E	0.95 Basic	
F	0.84	1.00
G	0.00	0.10
H	0.30	0.50
I	0°	8°
J	0.03	0.20

9.5.2 WLCSP-8

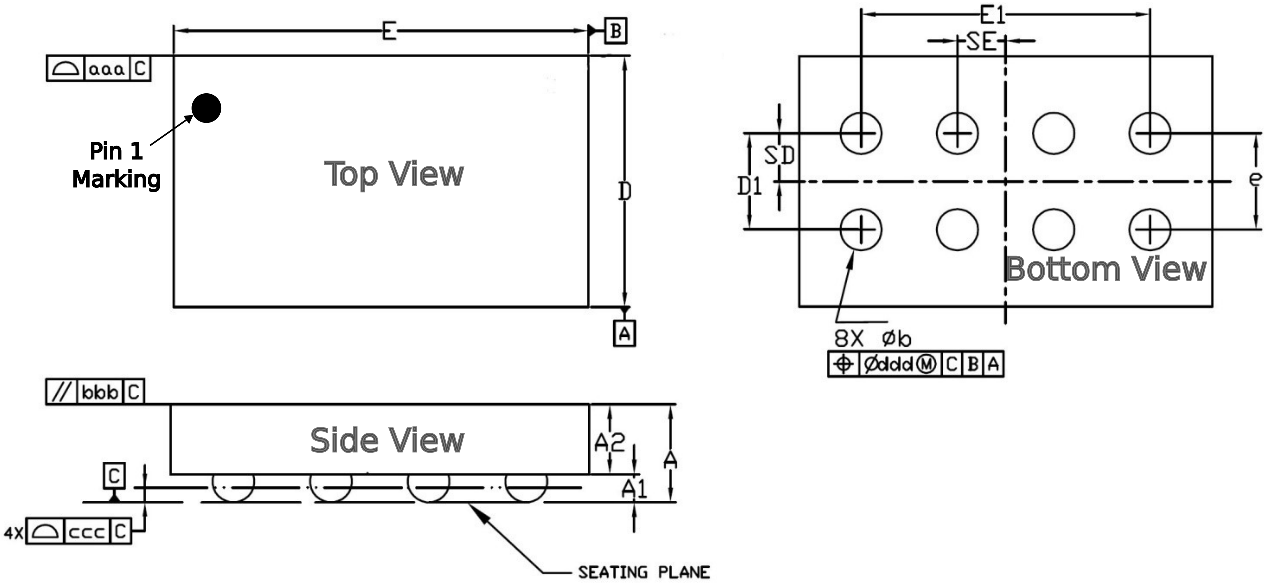


Figure 9.2: IQS227B WLCSP-8 Dimensions (in mm)

Table 9.7: IQS227B WLCSP-8 Dimensions

Dimensional Ref			
REF.	**Min (mm)**	**Nom (mm)**	**Max (mm)**
A	0.310	0.350	0.390
A1	0.085	0.100	0.115
A2	0.225	0.250	0.275
D	0.865	0.880	0.895
E	1.455	1.470	1.485
D1	0.300	0.350	0.400
E1	1.000	1.050	1.100
b	0.125	0.150	0.175
e	0.350 BSC		
SD	0.175 BSC		
SE	0.175 BSC		
Tol. Form & Position			
aaa	0.10		
bbb	0.10		
ccc	0.05		
ddd	0.05		

9.5.3 DFN-6

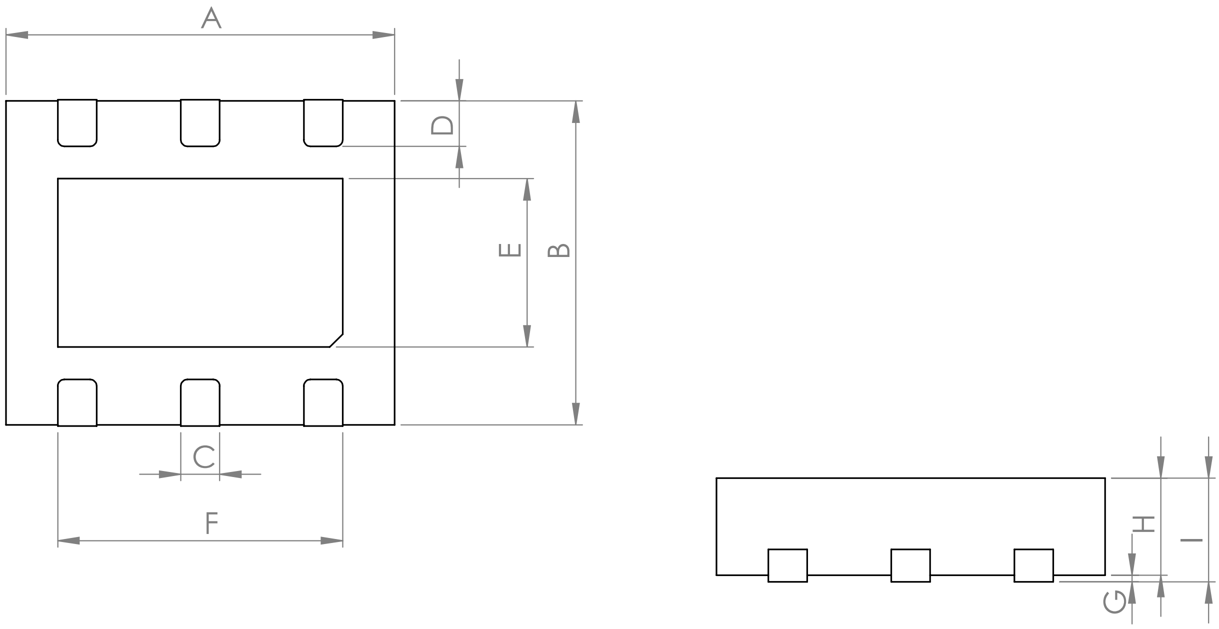


Figure 9.3: IQS227B/D DFN-6 Packaging

Table 9.8: IQS227B/D DFN-6 Dimensions

Dimension	Min (mm)	Max (mm)
A	3.00	3.00
B	2.50	2.50
C	0.30	0.30
D	0.35	0.35
E	1.30	1.30
F	2.20	2.20
G	0.05	0.05
H	0.75	0.75
I	0.80	0.80

9.5.4 MSL Level

Moisture Sensitivity Level (MSL) relates to the packaging and handling precautions for some semiconductors. The MSL is an electronic standard for the time period in which a moisture sensitive device can be exposed to ambient room conditions (approximately 30°C/85% RH see J-STD003C for more information) before reflow occurs.

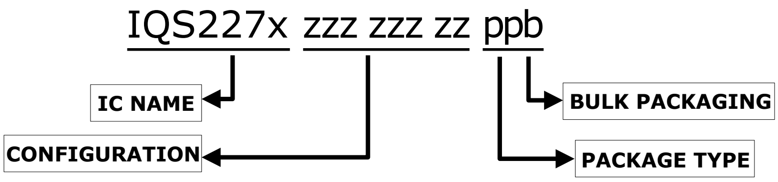
Package	Level (duration)
TSOT23-6	MSL 1 (Unlimited at ≤ 30°C/85% RH) Reflow profile peak temperature < 260°C for < 30 seconds
WLCSP-8	Non-encapsulated device - not moisture sensitive Reflow profile peak temperature < 260°C for < 30 seconds
DFN-6	MSL 1 (Unlimited at ≤ 30°C/85% RH) Reflow profile peak temperature < 260°C for < 30 seconds

10 Datasheet and Part-number Information

10.1 Ordering Information

Contact the official distributor for sample quantities. A list of the distributors can be found under the "Distributors" section of www.azoteq.com. Special MOQs apply for custom configurations.

The Part-number can be generated by using USBProg2.exe.



IC NAME	IQS227B	=	Self Capacitive IC with Dual Outputs (3.3V)
	IQS227D	=	Self Capacitive IC with Dual Outputs (5V)
CONFIGURATION	zzz zzz zz	=	IC Configuration (hexadecimal - See Section 4.1)
PACKAGE TYPE	TS	=	TSOT23-6 package
	CS	=	WLCSP-6 package
	DN	=	DFN-6 package
BULK Packaging	R	=	Reel
		=	TSOT23-6 (3000pcs/reel)
		=	WLCSP-6 (3000pcs/reel)
		=	DFN-6 (6000pcs/reel)
			MOQ = 1 reel. (Orders shipped as full reels)

10.2 Standard Devices

The default (unconfigured) device will be suitable for most applications. Some popular configurations are kept in stock and do not require further programming. (Ordering codes given for Device IDs: 03 0D / 03 0E or later (the Device ID will be read in USBProg2.exe)).

Table 10.1: IQS127D Standard Replacements

Device	IQS127D Function
IQS227(B/D)-00400008DNR/TSR	Default
IQS227(B/D)-00400028DNR/TSR	Active HIGH outputs
IQS227(B/D)-00410008DNR/TSR	Normal Power Mode
IQS227(B/D)-00400088DNR/TSR	Touch Output ac Toggle

10.3 Device Marking - Top

10.3.1 TSOT23-6 Package Markings

There are 2 marking versions in circulation for the IQS227B/D:

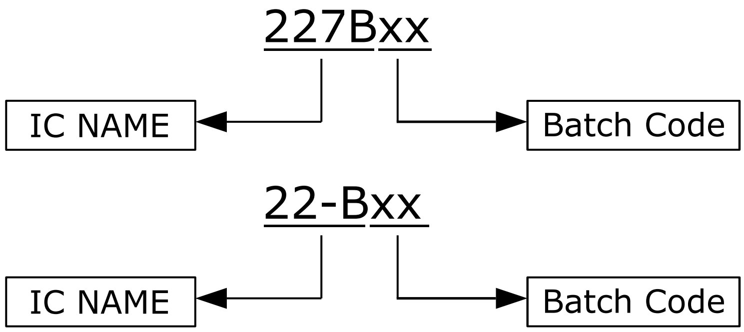


Figure 10.1: Top Marking Variants of IQS227B TSOT23-6 Package

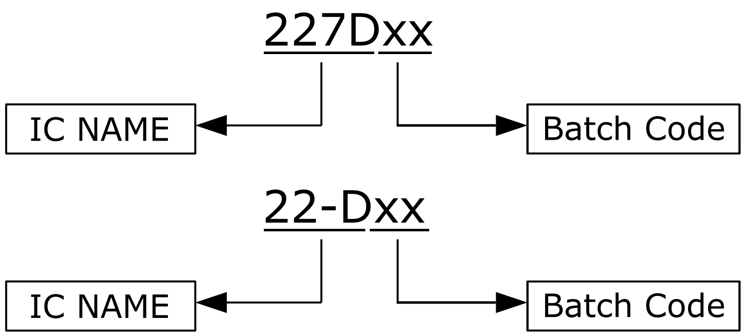


Figure 10.2: Top Marking Variants of IQS227D TSOT23-6 Package

IC NAME	227B	=	Self Capacitive IC with Dual Outputs (3.3V)
	22-B	=	Self Capacitive IC with Dual Outputs (3.3V)
	227D	=	Self Capacitive IC with Dual Outputs (5V)
	22-D	=	Self Capacitive IC with Dual Outputs (5V)
Batch Code	xx	=	AA to ZZ

10.3.2 WLCSP-8 Package Markings

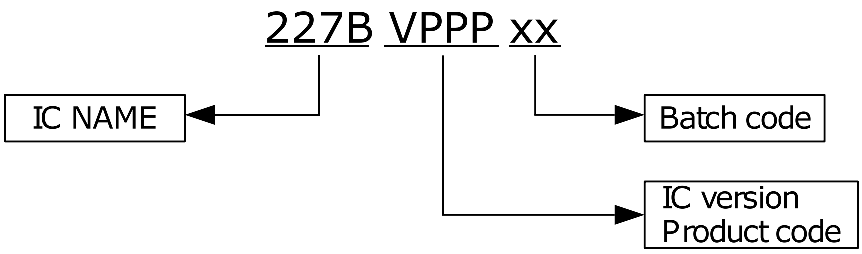


Figure 10.3: Top Marking of IQS227B WLCSP Package

IC NAME	227B	=	Self Capacitive IC with Dual Outputs (3.3V)
Batch Code	xx	=	AA - ZZ
IC VERSION	V		
Product Code	PPP		

10.3.3 DFN-6 Package Markings

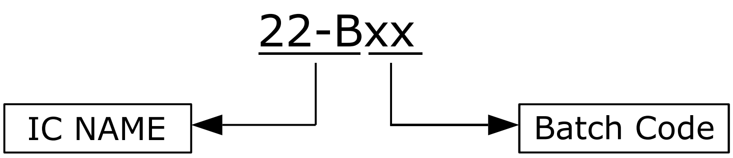


Figure 10.4: Top Marking of IQS227B DFN-6 Package

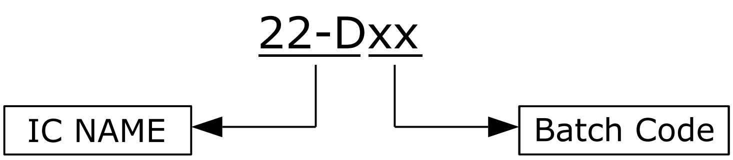
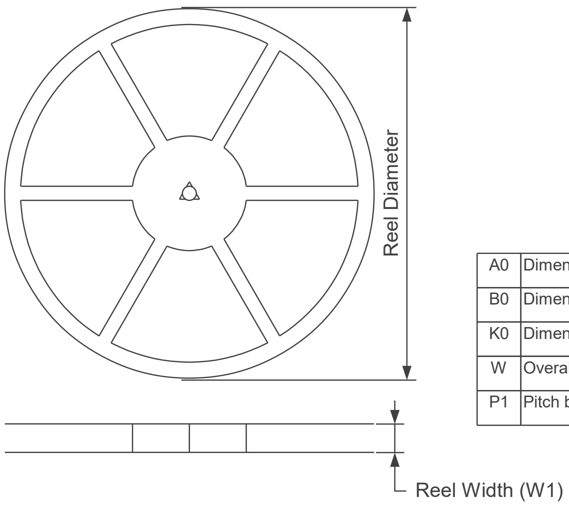
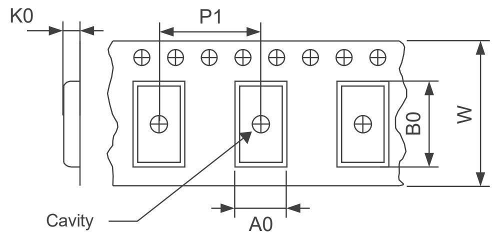


Figure 10.5: Top Marking of IQS227D DFN-6 Package

IC NAME	22-B	=	IQS227B Self Capacitive IC with Dual Outputs (3.3V)
	22-D	=	IQS227D Self Capacitive IC with Dual Outputs (5V)
Batch Code	xx	=	AA to ZZ

10.3.4 Tape and Reel Specification





A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

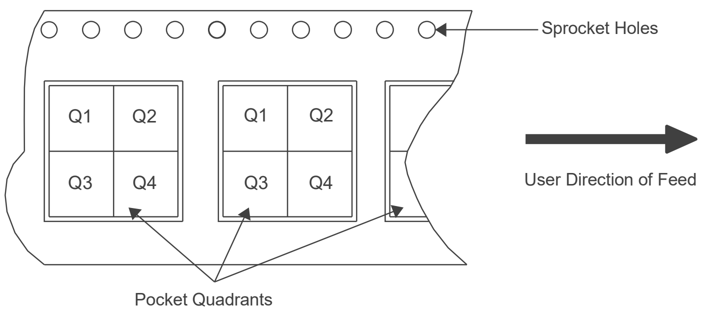


Figure 10.6: DFN-6 Tape Specification

Table 10.2: Tape and Reel Dimensions

Device	Package Type	Package Drawing	Pins	QTY per reel	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
IQS227B												
IQS227BzzzzzzzzTSR	TSOT23-6	TSOT23-6	6	3000	178	9.5	3.1	3.1	1.3	4	8	Q3
IQS227BzzzzzzzzCSR	WLCSP8	WLCSP-8	8	3000	179	8.4	1	1.55	0.48	4	8	Q3
IQS227BzzzzzzzzDNR	DFN6	DFN-6	6	6000	330	12	2.8	3.3	1.2	4	12	Q1
IQS227D												
IQS227DzzzzzzzzDNR	DFN6	DFN-6	6	6000	330	12	2.8	3.3	1.2	4	12	Q1
IQS227DzzzzzzzzTSR	TSOT23-6	TSOT23-6	6	3000	178	9.5	3.1	3.1	1.3	4	8	Q3

11 Known Issues

11.1 Undebounced touch without debounced proximity flag set

When a touch flag is set without the debounced proximity flag set, the LTA will reseed to the count value, quickly clearing the touch event. This effect is most pronounced with touch buttons and gives missed touches with rapidly repeated touches.

Workaround:

- Ensure the proximity threshold and touch threshold are as far apart as the application and features allow it.
- The effect is less noticeable if the focus of the application is on Proximity or Touch alone instead of both.

A Memory Map

Device Information

00H		Product Number (PROD_NR)							
	Bit	7	6	5	4	3	2	1	0
Access	Value	39 (Decimal)							
R	Note								

01H		Software Number (SW_NR)							
	Bit	7	6	5	4	3	2	1	0
Access	Value	28 (Decimal)							
R	Note								

[00H] PROD_NR
The product number for the IQS227B/D is 39 (Decimal).

[01H] SW_NR
The software version number of the device ROM can be read in this byte. The latest software version is 28 (Decimal).

10H		System Flags (Sys_Flags)							
	Bit	7	6	5	4	3	2	1	0
Access	Value	~	~	Logic	Halt	LP	ATI	~	Zoom
R	Note								

[10H] SYSFLAGS0

Bit 7-6: **Reserved**

Bit 5: **Logic**: Logic Output Indication.
0 = Active Low
1 = Active High

Bit 4: **Halt**: Indicates Filter Halt Status.
0 = LTA not being Halted
1 = LTA Halted

Bit 3: **LP**: Low Power Mode
0 = Sample time BP
1 = Sample time LP

Bit 2: **ATI**: Status of automated ATI routine.

0 = ATI is not busy

1 = ATI in progress

Bit 1: **Reserved**

Bit 0: **Zoom**: Zoom will indicate full-speed charging once an undebounced proximity is detected. In BP mode, this will not change the charging frequency.

0 = IC not zoomed in

1 = IC detected undebounced proximity and IC is charging at full speed (BP)

31H		Status							
	Bit	7	6	5	4	3	2	1	0
Access	Value	~	~	~	~	~	~	Touch	Prox
R	Note								

[31H] Status

Bit 7-2: **Reserved**

Bit 1: **Touch**: Touch Detection.

0 = Not Active

1 = Active

Bit 0: **Prox**: Proximity Detection.

0 = Not Active

1 = Active

42H		Counts_High (CS_H)							
	Bit	7	6	5	4	3	2	1	0
Access	Value	Counts High Byte							
R	Note								

43H		Counts_Low (CS_L)							
	Bit	7	6	5	4	3	2	1	0
Access	Value	Counts Low Byte							
R	Note								

83H		LTA_High (LTA_H)							
	Bit	7	6	5	4	3	2	1	0
Access	Value	Long Term Average High Byte							
R	Note								

84H		LTA_Low (LTA_L)							
	Bit	7	6	5	4	3	2	1	0
Access	Value	Long Term Average Low Byte							
R	Note								

C4H		Fuse Bank 0 (FB_0)							
	Bit	7	6	5	4	3	2	1	0
Access	Value	See Table 4.1 for more details							
R	Note								

C5H		Fuse Bank 1 (FB_1)							
	Bit	7	6	5	4	3	2	1	0
Access	Value	See Table 4.2 for more details							
R	Note								

C6H		Fuse Bank 2 (FB_2)							
	Bit	7	6	5	4	3	2	1	0
Access	Value	See Table 4.3 for more details							
R	Note								

C7H		Fuse Bank 3 (FB_3)							
	Bit	7	6	5	4	3	2	1	0
Access	Value	Not Used							
R	Note								

C8H		DEFAULT_COMMS_POINTER							
	Bit	7	6	5	4	3	2	1	0
Access	Value	(Beginning of Device Specific Data)							
R/W	Default	10H							

[C8H] Default Comms Pointer

The value stored in this register will be loaded into the Comms Pointer at the start of a communication window. For example, if the design only requires the Proximity Status information each cycle, then the Default Comms Pointer can be set to **ADDRESS 31H**. This would mean that at the start of each communication window, the comms pointer would already be set to the Proximity Status register, simply allowing a **READ** to retrieve the data, without the need of setting up the address.

Contact Information

	USA	Asia	South Africa
Physical Address	11940 Jollyville Suite 120-S Austin TX 78759 USA	Room 501A, Block A T-Share International Centre Taoyuan Road, Nanshan District Shenzhen, Guangdong, PRC	1 Bergsig Avenue Paarl 7646 South Africa
Postal Address	11940 Jollyville Suite 120-S Austin TX 78759 USA	Room 501A, Block A T-Share International Centre Taoyuan Road, Nanshan District Shenzhen, Guangdong, PRC	PO Box 3534 Paarl 7620 South Africa
Tel	+1 512 538 1995	+86 755 8303 5294 ext 808	+27 21 863 0033
Email	info@azoteq.com	info@azoteq.com	info@azoteq.com

Visit www.azoteq.com
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