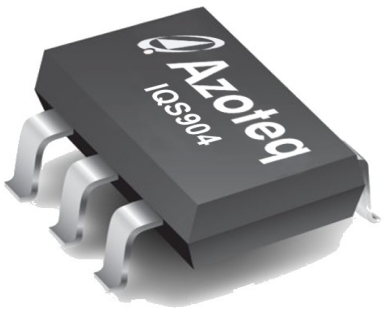
IQS904 Datasheet
IQ Switch® - ProxSense® Series
Single Channel Capacitive Sensor and Controller for Dimmer Applications

Unparalleled Features

- Extensive feature set in a TSOT23-6 package
- Extremely low current consumption
- Automatic tuning for optimal operation in various environments & compensation against sensitivity reducing objects

The IQS904 ProxSense® IC is a fully integrated single channel capacitive contact and proximity sensor with built in controller for dimming applications. With market leading sensitivity and automatic tuning of the sense antenna, the IQS904 provides an extremely cost effective minimalist implementation requiring very few external components. The device is ready for use in a large range of AC/DC dimming applications, while programming options allow flexible fine tuning in specialized applications.

Main Features



- Single Channel input device
- IQS904A : AC applications
- IQS904D : DC applications
- ATI: Automatic tuning to optimum sensitivity
- Supply Voltage 2.95V to 5.5V
- Internal voltage regulator and reference capacitor
- OTP options
  - Output Polarity (Active High or Active Low) for IQS904AC
  - Proximity & Touch Thresholds
  - FITD time(18s or 5s) for IQS904DC
- Automatic drift compensation
- Development and Programming tools available (USBProg)
- Compact TSOT23-6 Package

Applications

- DC/AC Lamp Dimming
- Camping Lights
- Flash Lights
- Night Lights
- Under Cabinet Lighting
- Proximity detection that enables backlighting activation (Patented)
- Replacement for electromechanical switches

T_A	TSOT23-6
-40°C to 85°C	IQS904
Current Consumption: 200 µA	

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Functional Overview

1 Introduction

The IQS904 is a single channel capacitive proximity and touch sensor featuring integrated DC/AC dimming control, internal voltage regulator, power supply zero-cross detection and reference capacitor (Cs).

The device has a single input pin for the connection of the sense antenna (Cx), and dedicated output pin (LOAD) to provide the signal to drive the DC or AC switch. The output pin is digital PWM, with selectable polarity (Active High or Active Low).

The IQS904A use leading edge control to drive a NFET.

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

1.1 Pin-out

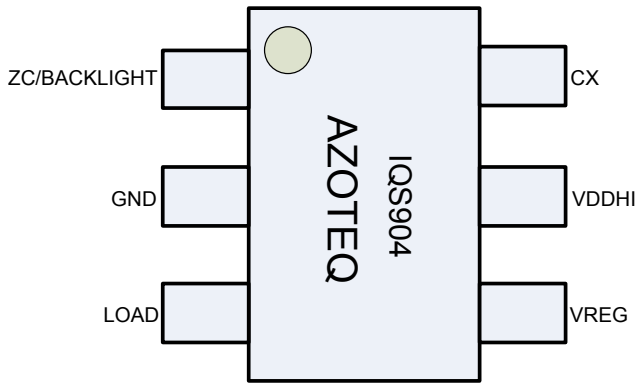


Figure 1.1 IQS904 Pin-out

Table 1.1 IQS904 Pin-out.

Pin	Standalone		Function
1	**AC**	ZC	Zero-cross Detection
	DC	Backlight	Backlight function
2	GND		Ground
3	LOAD		Switch Drive Signal
4	VREG		Regulator Pin
5	VDDHI		Power Input
6	CX		Sense Electrode Connection Pin

1.2 Applicability

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

- Temperature -40 ºC to +85 ºC
- Supply voltage (V_{DDHI})2.95V to 5.5V

2 Analogue Functionality

The analogue circuitry measures the capacitance of the sense antenna attached to the Cx pin 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 current sample (CS).

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The capacitance measurement circuitry makes use of an internal sampling capacitor.

The analogue circuitry further provides functionality for:

- Power on reset (POR) detection
- Brown out detection (BOD)
- Zero-cross detection

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.
- Manage programming of OTP options.

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4 Detailed Description

4.1 System overview

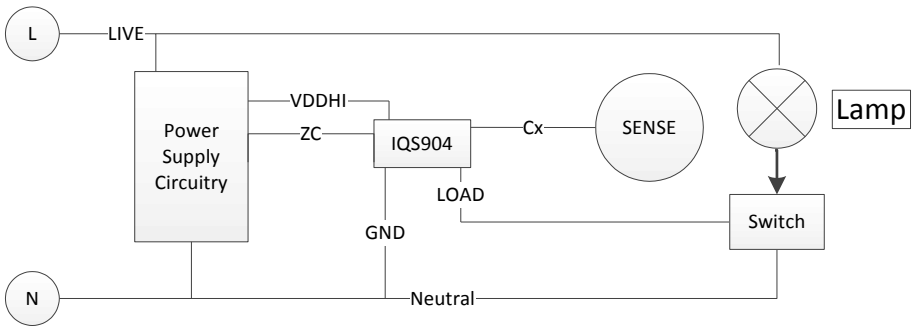


Figure 4.1 System overview

4.2 Typical Circuit for DC Applications

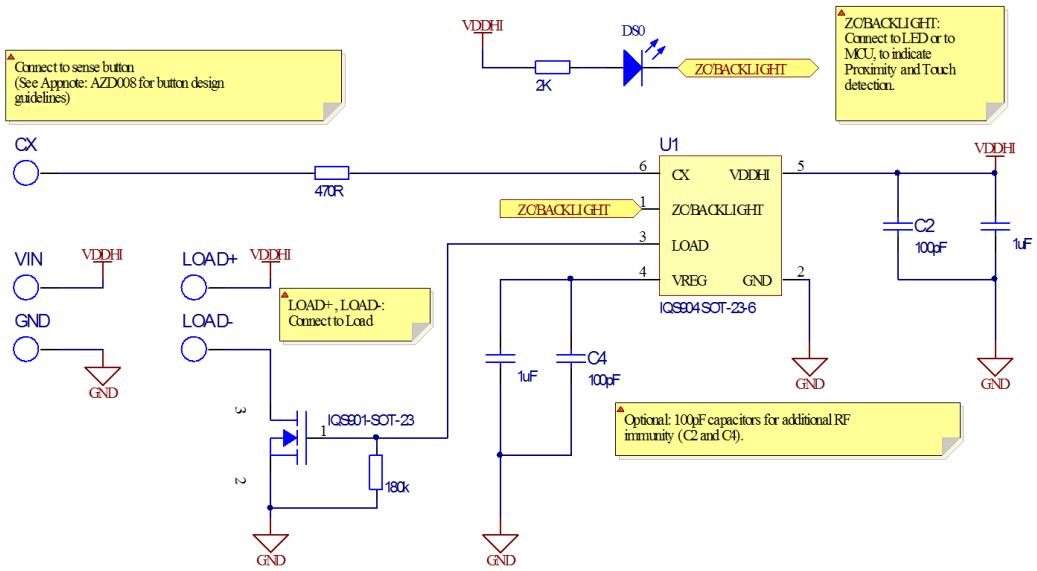


Figure 4.2 Reference Design (DC Application)

4.3 Typical Circuit for AC Applications

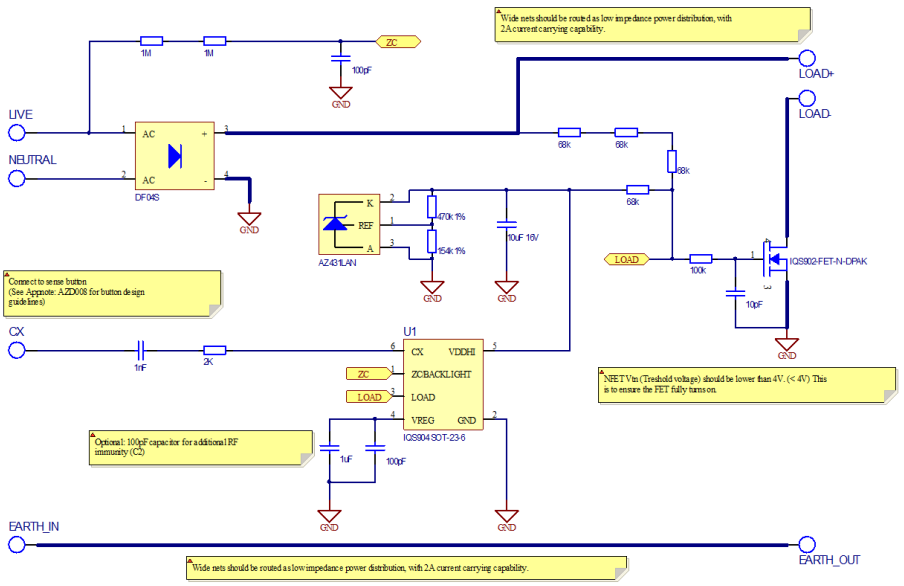


Figure 4.3 Reference Design (AC Application)

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 proximities at distances that cannot be equalled by most other products. When the device is used in environments where noise or ground effects exist that lower the sensitivity, a reduced proximity threshold is proposed to ensure reliable functioning of the sensor.

6 User Interface Description

The various power levels are summarised in Table 6.1.

Table 6.1 Power Levels for different operational modes

	POWER % Duty Cycle		
Power	**50 Hz**	**60 Hz**	**DC**
FITD (Find-In-The-Dark)	42.1	30.5	0.58
Low	47	37.5	1
High	100	100	100

6.1 User Interface: User Selectable Dimming Level

- **Long touch:** longer than 1 second.
- **Short touch:** shorter than 1 second.

Operation of UI:

- Proximity detection will switch load on at FITD% for 16 seconds (50/60Hz dependent)
- From initial OFF state, **short touch** goes to full power.
- From any ON state, **long touch** & holding touch will change duty cycle / dimming
- From any OFF state, **long touch** start at low power and increase to full power. Holding touch will change duty cycle / dimming
- From any ON state, **short touch** switches off.
- Any **long touch** held for longer than 60s switches off (This setting can be disabled by setting the halt setting to always halt)

Timings:

- Long touch ramp time: 3 seconds.
- Flat top and bottom pause time: 1.5 seconds.
- Total cycle time: 9 seconds.
- Auto-off time: 1 hour
- Automatic dim time after Auto-off: 30 seconds.
- Auto-off is enabled when switched on by **long touch**
- FITD time on Prox trigger: 16 seconds or 5 seconds

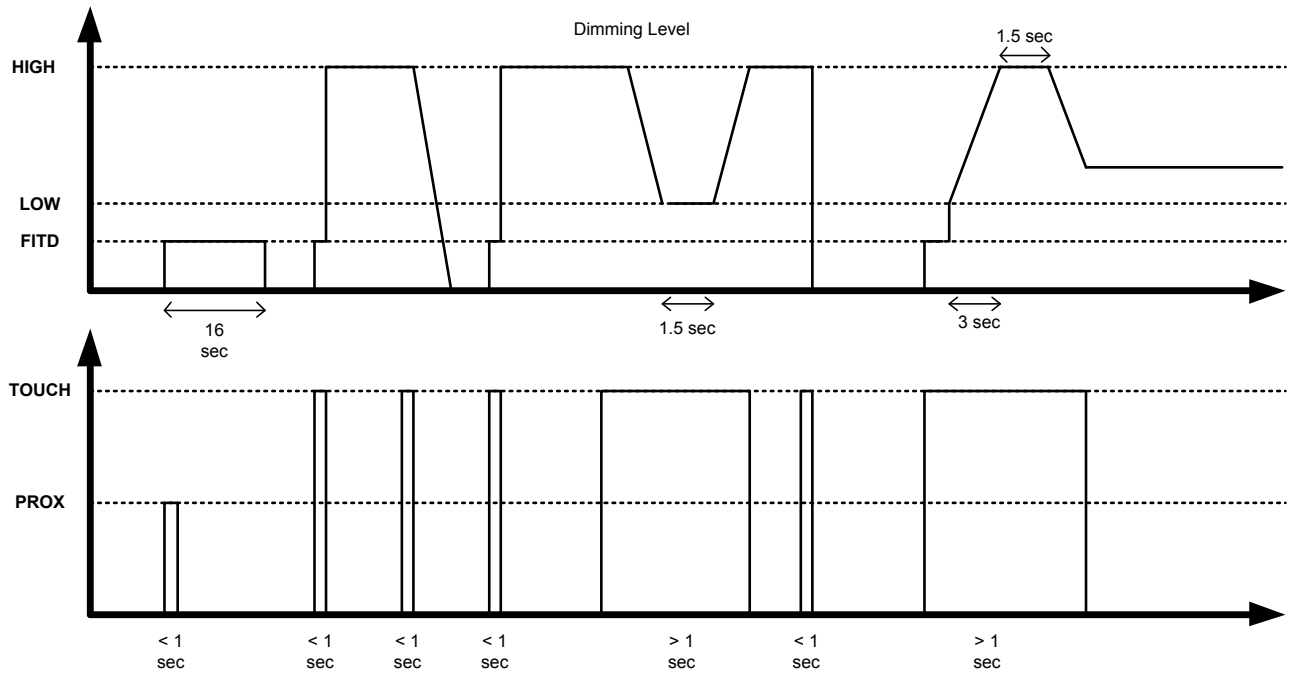


Figure 6.1 Dimming Level versus Proximity and Touch

7 User Configurable Options

The IQS904 provides One Time Programmable (OTP) user options (each option can be modified only once). 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.

7.1 Configuring of Devices

Azoteq offers a Configuration Tool (CTxxx) 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 application note: "AZD007 – USBProg Overview" which can be found on the Azoteq website.

Alternate programming solutions of the IQS904 also exist. For further enquiries regarding this matter please contact Azoteq at ProxSenseSupport@azoteq.com or the local distributor.

7.2 IQS904AC User options

Table 7-1: User Selectable Configuration for IQS904AC Options: Bank 0

t_{HALT1}	t_{HALT0}	AC	T_{THR2}	T_{THR1}	T_{THR0}	P_{THR1}	P_{THR0}
bit 7							bit 0

Bank 0 bit 7-6 **t_{HALT1}:t_{HATL0}:** Halt time of Long Term Average

00 = 18 seconds

01 = 60 seconds

10 = Never Halt

11 = Always Halt

Bank 0: bit 5 **AC:** Selection

1 = AC Mode

Bank 0: bit 4-2 **T_{THR2}:T_{THR0}:** Touch Thresholds on CH0

000 = 64

001 = 16 (Most Sensitive)

010 = 32

011 = 124

100 = 188

101 = 250

110 = 375

111 = 500 (Least Sensitive)

Bank 0: bit 1-0 **P_{THR1}: P_{THR0}:**Proximity Thresholds

00 = 4

01 = 2 (Most Sensitive)

10 = 8

11 = 32 (Least Sensitive)

Table 7-2: User Selectable Configuration Options: Bank 1

x	x	x	x	x	x	P_{LOAD}	x

bit 7 bit 0

Bank 1: bit 1 **P_{LOAD}**: Prox-on-Load Selection

0 = Enabled

1 = Disabled

Table 7-3: User Selectable Configuration Options: Bank 2

x	x	x	x				ATI

bit 7 bit 0

Bank 2: bit 3 **ATI:** Auto ATI Selection

0 = Enabled

1 = Disabled

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7.3 IQS904DC User options

Table 7-4: User Selectable Configuration for IQS904DC Options: Bank 0

t_{HALT1}	t_{HALT0}	x	T_{THR2}	T_{THR1}	T_{THR0}	P_{THR1}	P_{THR0}
bit 7							bit 0

Bank 0 bit 7-6 **t_{HALT1}:t_{HATL0}:** Halt time of Long Term Average

00 = 18 seconds

01 = 60 seconds

10 = Never Halt

11 = Always Halt

Bank 0: bit 5 Not Used

Bank 0: bit 4-2 **T_{THR2}:T_{THR0}:** Touch Thresholds on CH0

000 = 64

001 = 16 (Most Sensitive)

010 = 32

011 = 124

100 = 188

101 = 250

110 = 375

111 = 500 (Least Sensitive)

Bank 0: bit 1-0 **P_{THR1}: P_{THR0}:**Proximity Thresholds

00 = 4

01 = 2 (Most Sensitive)

10 = 8

11 = 16 (Least Sensitive)

Table 7-5: User Selectable Configuration Options: Bank 1

x	x	x	x	x	$FITD_{TIME}$	P_{LOAD}	x

bit 7 bit 0

Bank 1: bit 2 **$FITD_{Time}$:** Find In The Dark time

0 = 16s

1 = 5s

Bank 1 : bit 1 **P_{LOAD}**: Prox-on-Load Selection

0 = Enabled

1 = Disabled

Table 7-6: User Selectable Configuration Options: Bank 2

x	x	x	x				ATI

bit 7 bit 0

Bank 2: bit 3 **ATI:** Auto ATI Selection

0 = Enabled

1 = Disabled

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8 Description of User Options

This section describes the individual user programmable options of the IQS904 in more detail.

A number of standard device configurations are available (refer to Chapter 6). Azoteq can supply pre-configured devices for large quantities.

8.1 DC/AC

The IQS904 is offered as a AC or DC controller:

IQS904Dxx DC-Dimmer

IQS904Axx AC-Dimmer

8.2 Adjustable Proximity Threshold

The IQS904 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.

Configuration: Bank0 bit1-0

PTHR1:PTHR0: Proximity Thresholds

Bit	Selection
00	4
01	2 (Most sensitive)
10	8
11	16: **IQS904DC** (least sensitive)
11	32: **IQS904AC** (least sensitive)

8.3 Adjustable Touch Threshold

The IQS904 has 8 touch threshold settings. The touch threshold is selected by the designer to obtain the desired touch sensitivity. The touch threshold is expressed in terms of counts; the same as CS.

The touch event is triggered based on T_{TH}, CS and LTA. A touch event is identified when for at least 4 consecutive samples of the following equation holds:

$$T_{TH} =< LTA - CS$$

The Touch Threshold is set as follows:

Configuration: Bank0 bit 4-2

TTHR2:TTHR0: Touch Thresholds

Bit	Selection
000	64
001	16 (Most sensitive)
010	32
011	124
100	188
101	250
110	375
111	500 (Least sensitive)

8.4 Logic Output

In the DC and AC devices, the output logic for the load driving signal (PIN 3 on the IQS904 IC) is fixed in ACTIVE HIGH mode.

In **DC mode**, **PIN 1 (ZC/BACKLIGHT)** becomes available to indicate when a proximity or touch is detected, and is suitable to be used with a microcontroller or to drive a LED directly. The output logic of this pin is **ACTIVE LOW**. When proximity is detected, the output signal will go low for as long as the t_{halt} time is selected.

When a touch is detected, the output signal will be a square wave oscillating at 7.5 Hz to give user feedback on touch detected.

8.5 Prox on Load Enable/Disable

When a proximity event is detected by the IQS904, it will by default drive the load to turn on in a low power/light mode.

This feature can be disabled by setting bit1 in Bank1, as indicated below.

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Configuration: Bank1 bit1

Proximity on Load

Bit	Selection
0	Enabled
1	Disabled

8.6 FITD time on load (5s Option only available on IQS904DC)

The find in the dark time is selectable between 16s and 5s. This option is available in bank 1 bit 2.

Logic: Find in the Dark Time

Bit	Selection
0	16s
1	5s

8.7 Filters used by the IQS904

The IQS904 devices employ various signal processing functions that includes the execution of various filters as described below.

8.7.1 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 IQS904 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 current sample). 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 current samples (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 may cause the CS 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.

The designer needs to select a Halt Timer value to best accommodate the required application.

Configuration: Bank0 bit7-6

t_{HALT1}:t_{HATL0}: Halt time of Long Term Average

Bit	Selection
00	18 seconds
01	60 seconds
10	Never Halt
11	Always Halt

Notes:

- With the Never (bit selection “10”) option, the filter will not halt when any proximity or touch condition occurs.
- With the ‘ALWAYS’ (bit selection “11”) 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 “AZD024 - Graphical Representation of the IIR Filter” for detail regarding the execution of the LTA filter.

8.8 ATI

The built in Auto ATI algorithm fine tunes the sense antenna for maximum sensitivity. It is enabled by default.

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9 Antenna Tuning Implementation (ATI)

ATI is a 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 AZD0027 - Antenna Tuning Implementation).

ATI makes adjustments through internal reference capacitors to obtain optimum performance. It 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 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.

9.1 Automatic ATI

The IQS904 implements an automatic ATI algorithm. This algorithm automatically adjusts the ATI parameters to optimise the sensing antenna's 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 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 have been detected.

The automatic ATI function aims to maintain a constant current sample, regardless of the capacitance of the sense antenna (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 antenna at start-up to optimise the sensitivity of the application.
- Automatic re-tuning when the device detects changes in the sensing antennas' capacitance to accommodate a large range of changes in the environment of the application that influences the sensing antennas.
- 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 antenna capacitances.

10 Electrical Characteristics

10.1 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})	5.5V
Maximum pin voltage (ZC/BACKLIGHT, load)	V_{DDHI} + 0.5V
Pin voltage (Cx)	2.5V
Minimum pin voltage (VDDHI, VREG,ZC/BACKLIGHT,LOAD, Cx)	V_{SS} - 0.5V
Minimum power-on slope	100V/s
HBM ESD protection (VDDHI, VREG, V_{SS}, ZC/BACKLIGHT, Cx)	2Kv

10.2 General Characteristics (Measured at 25°C)

Standard IQS904 devices are rated for supply voltages between 2.95V and 5V. The low voltage version of the IQS904 is rated for supply voltages between 2.0V and 5V. For supply voltages below 2.95V the device is operating below the voltage required by the internal regulator and some of the characteristics of the device may be different than those for the Standard IQS904.

Table 10.1 IQS904 General Operating Conditions

DESCRIPTION	IC	Conditions	PARAMETER	MIN	TYP	MAX	UNIT
Supply voltage	D		V_{DDHI}	2.95		5.50	V
Internal regulator output	D	2.95 ≤ V_{DDHI} ≤ 5.0	V_{REG}	2.35	2.50	2.65	V
Internal regulator output	D	2.0 ≤ V_{DDHI} ≤ 2.95	V_{REG}	1.80	V_{DDHI}	V_{DDHI}	V
Normal operating current	D	2.95 ≤ V_{DDHI} ≤ 5.0	I_{IQS904_NP}		200		µA

Table 10.2 Start-up and shut-down slope Characteristics

DESCRIPTION	IC	Conditions	PARAMETER	MIN	MAX	UNIT
POR	D/S	V_{DDHI} Slope ≥ 100V/s	POR	1.15	1.8	V
BOD	D/S		BOD	1.2	1.8	V

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10.3 Output Characteristics (measured at 25^{0}C)

Table 10.3 IQS904DC Characteristics

Symbol	Description	I_{SINK} (mA)	Conditions	MIN	TYP	MAX	UNIT
BACKLIGHT	Output Low voltage	3.0	V_{DDHI} = 5V	0.1	0.5		V
		2.5	V_{DDHI} = 3.3V	0.1	0.33		
		2.5	V_{DDHI} = 2.5V	0.1	0.25		

10.4 Electromagnetic Compatibility

10.4.1 Electrostatic discharge (ESD)

Table 10.4 ESD Characteristics

Symbol	Ratings	Conditions	Level/ Class	Maximum Value	UNIT
$V_{ESD(HBM)}$	Electrostatic discharge voltage (Human body model)	T_A = +25°C, conforming to JESD22-A114	2	2000	V
$V_{ESD(CDM)}$	Electrostatic discharge voltage (Charge device model)	T_A = +25°C, conforming to JESD22-C101-D	IV	1000	V
$V_{ESD(Product)}$	Electrostatic discharge voltage (Product specification)	T_A = +25°C, conforming to IEC61000-4-2, Air-discharge on all pins	4	±8	kv
$V_{ESD(Product)}$	Electrostatic discharge voltage (Product specification)	T_A = +25°C, conforming to IEC61000-4-2, Contact-discharge on all pins	3	±6	Kv

10.4.2 Static Latch-Up(LU)

Table 10.5 Static Latch-Up(LU)

Class	Symbol	Parameter	Conditions
A	LU	Static latch-up class	T_A = +25°C, conforming to EIA/JESD 78 IC latch-up standard

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10.5 Timing Characteristics

Table 10.6 Main Oscillator

SYMBOL	DESCRIPTION	Conditions	MIN	TYP	MAX	UNIT
F_{OSC}	IQS904 Main oscillator	$3 \leq V_{DDHI} \leq 5.0$		4		MHz

11 Mechanical Dimensions

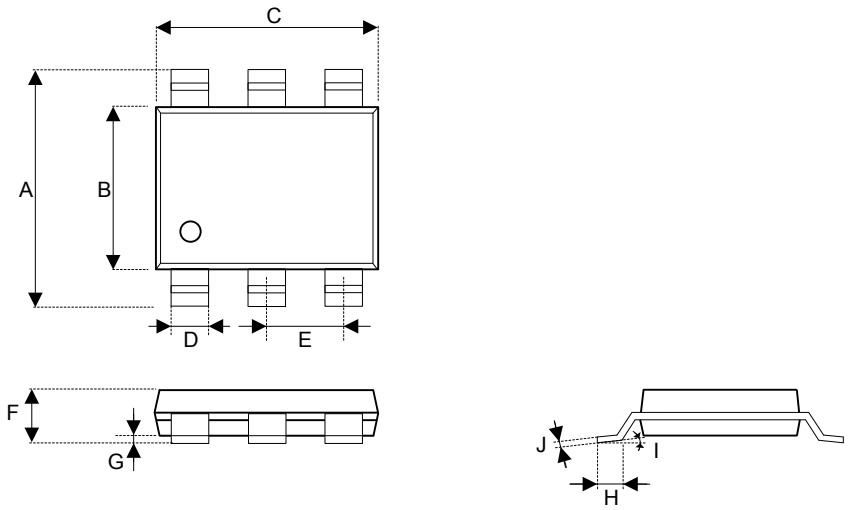


Figure 11.1 TSOT23-6 Packaging

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Table 11.1 TSOT23-6 Dimensions

Dimension	Min	Max	Tolerance
A	2.80 mm typ		Basic
B	1.60 mm typ		Basic
C	2.90 mm typ		Basic
D	0.40 mm		±0.10mm
E	0.95 mm typ		Basic
F	1.00mm		Max
G	0.05 mm		±0.05mm
H	0.40 mm		±0.10mm
I	4°		±4°
J	0.127 mm typ		+0.07/-0.007

11.2 Package MSL

Moisture Sensitivity Level (MSL) relates to the packaging and handling precautions for SMD semiconductors.

Table 0: MSL

Package	**Level (duration)**
TSOT23-6	MSL1

12 Revision History

The changes/limitations for specific revision numbers are described below:

Revision	Device ID	Package Markings	Changes and/or Limitations
0	1006	IQS904 AC (Engineering samples)	N/A
1.01	3801	IQS904A,xx (Production AC Controller)	• Lowest sensitivity threshold for Proximity detection changed to 32 • Polarity output selection removed • Prox on Load feature added
1.02	3802	IQS904D,xx (Production DC Controller)	• Lowest sensitivity threshold for Proximity detection changed to 16 • Change DC Dimmer UI to give 100% uniform dimming to get rid of the 70% to 100% jump. • Put an extra option in for the FITD on Load. FG10 = 0 – FITD Delay = 16s FG10 =10 – FITD Delay = 5s • Reseed wil be 8 normally and 16 after Load switch off • ATI limits during ATI = +-128, ATI Limits nomal mode = +128 -148.
1.10			• Updated contacts page

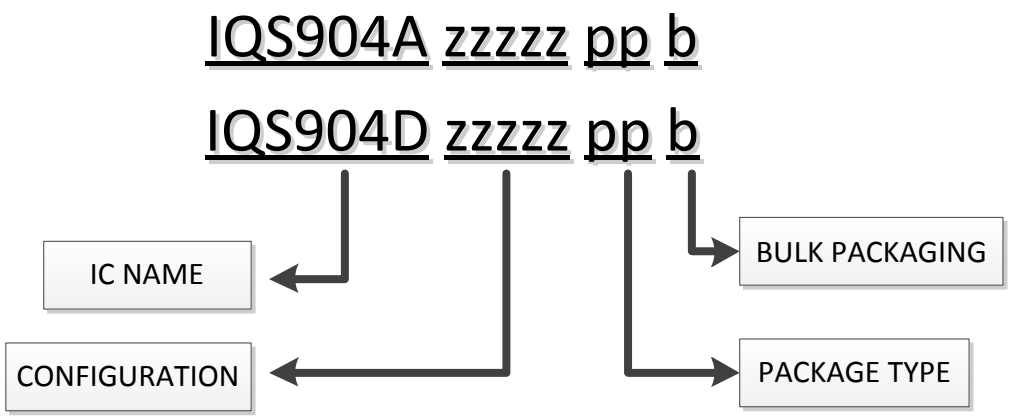
13 Datasheet and Part-number Information

13.1 Ordering Information

Orders will be subject to a MOQ (Minimum Order Quantity) of a full reel of 3000. 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	IQS904A	=	**AC** Dimmer Controller
	IQS904D	=	**DC** Dimmer Controller
CONFIGURATION	zzzzz	=	IC Configuration (hexadecimal)
PACKAGE TYPE	TS	=	TSOT23-6
BULK PACKAGING	R	=	Reel (3000pcs/reel) – MOQ = 3000pcs

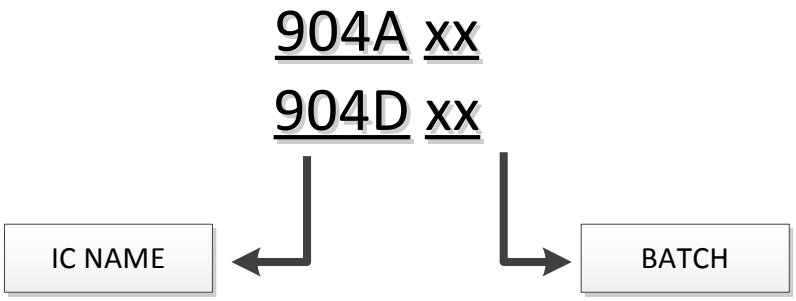
13.2 Standerd Devices

Standard Devices	Function
IQS904D-00000TSR	Default
IQS904A-00000TSR	Default

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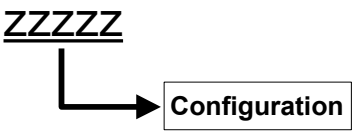
13.3 Device Packaging Convention

13.3.1 Top



IC Name	IQS904A	IQS904 AC version
	IQS904D	IQS904 DC version
BATCH	xx	Sequential batch number

13.3.2 Bottom



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14 Contact Information

	USA	Asia	South Africa
Physical Address	6507 Jester Blvd Bldg 5, suite 510G Austin TX 78750 USA	Rm2125, Glittery City Shennan Rd Futian District Shenzhen, 518033 China	109 Main Street Paarl 7646 South Africa
Postal Address	6507 Jester Blvd Bldg 5, suite 510G Austin TX 78750 USA	Rm2125, Glittery City Shennan Rd Futian District Shenzhen, 518033 China	PO Box 3534 Paarl 7620 South Africa
Tel	+1 512 538 1995	+86 755 83035294 ext 808	+27 21 863 0033
Fax	+1 512 672 8442		+27 21 863 1512
Email	kobusm@azoteq.com	linayu@azoteq.com.cn	info@azoteq.com

Please visit www.azoteq.com for a list of distributors and worldwide representation.

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 7,265,494 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 B2; US 7,781,980 B2; US 7,915,765 B2; US 7,994,726 B2; US 8,035,623 B2; US RE43,606 E; US 8,288,952 B2; US 8,395,395 B2; US 8,531,120 B2; US 8,659,306 B2; US 8,823,273 B2; EP 1 120 018 B2; EP 1 206 168 B1; EP 1 308 913 B1; EP 1 530 178 A1; EP 2 351 220 B1; EP 2 559 164 B1; CN 1330853; CN 1783573; AUS 761094; HK 104 1401

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WWW.AZOTEQ.COM

info@azoteq.com

Общество с ограниченной ответственностью «МосЧип» ИНН 7719860671 / КПП 771901001
Адрес: 105318, г.Москва, ул.Щербаковская д.3, офис 1107

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Офис по работе с юридическими лицами:

105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: info@moschip.ru

Skype отдела продаж:
moschip.ru
moschip.ru_4
moschip.ru_6
moschip.ru_9