IQS319 DATASHEET

Single channel proximity sensing controller with Movement and Release User Interfaces. The device is specifically designed for SAR and other similar proximity sensing requirements. It features a configurable event timeout, adjustable sensitivity and low power consumption.

1 Device Overview

The IQS319 ProxFusion® IC is a standalone capacitive sensing device for single channel proximity sensing requirements. The sensor is configurable via external input pins and on-chip calculations enable the IC to respond effectively in various use cases.

1.1 Main Features

- Single channel self-capacitive SAR Sensor
- 1 external sensor pad connection
- Built-in basic functions:
  - Automatic tuning
  - Noise filtering
  - Debounce & Hysteresis
  - High performance in high capacitive load conditions
- Built-in Signal processing options:
  - Standalone Proximity Output
  - Movement User Interface
  - Release User Interface
- Design simplicity
  - Configurable event timeout and channel sensitivity using external input pins
  - One-time programmable settings for custom IC configuration
- I^2C debugging interface with IRQ/RDY (up to Fast Mode Plus – 1 MHz)
- Supply Voltage 1.8 V (-5%) to 3.5 V
- Package options
  - WLCSP11 (1.48 x 1.08 x 0.345 mm) - interleaved 0.35 mm x 0.35 mm ball pitch
  - QFN20 (3 x 3 x 0.55 mm) - 0.4 mm pitch

Figure 1.1: WLCSP11

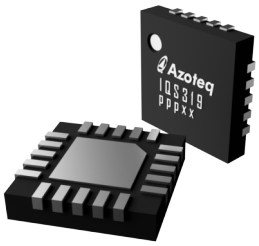


Figure 1.2: QFN20

1.2 Applications

- SAR Safety Sensor
- Keyboard backlighting
- Wireless charger wakeup

1.3 Block Diagram

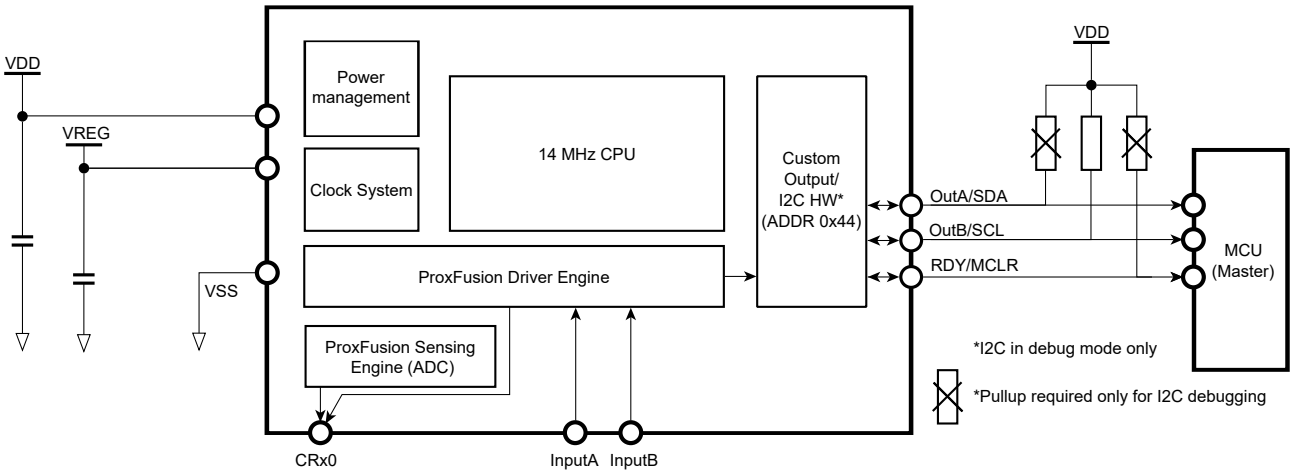
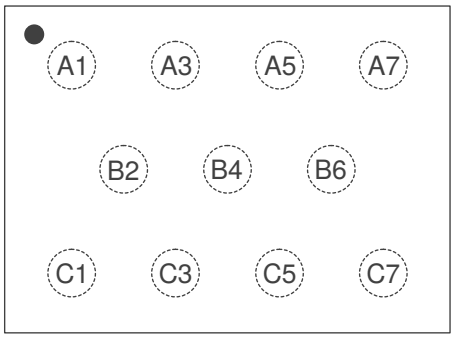


Figure 1.3: Functional Block Diagram

Contents

2 Hardware Connection

2.1 WLCSP11 Pin Diagram

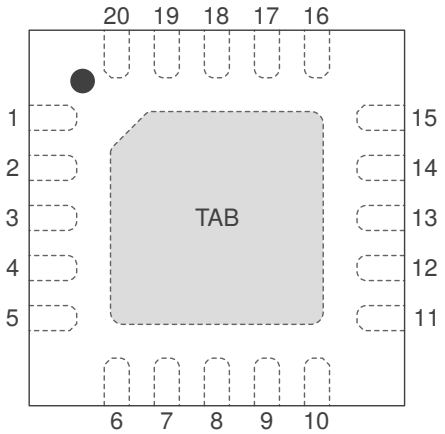


Top View

Table 2.1: 11-pin WLCSP Package

Pin no.	Signal
A1	InputA
A3	VREG
A5	OutA
A7	VSS
B2	CRx0
B4	Unused
B6	Unused
C1	InputB
C3	OutB
C5	VDD
C7	MCLR

2.2 QFN20 Pin Diagram



Top View

Table 2.2: 20-pin QFN Package (Top View)

Pin no.	Signal	Pin no.	Signal
1	InputB	11	NC
2	CRx0	12	NC
3	InputA	13	NC
4	NC	14	NC
5	NC	15	NC
6	VREG	16	NC
7	Unused	17	MCLR
8	VDD	18	Unused
9	VSS	19	OutA
10	NC	20	OutB

Area name	Signal
TAB[i]	Thermal pad (floating)

[i] It is recommended to connect the thermal pad (TAB) to VSS.

2.3 Signal Descriptions

Table 2.3: Signal Descriptions

Function	Signal Name	Signal Type	Pin Type[ii]	Description
ProxFusion®	CRx0	Analog	IO	ProxFusion® channel
	InputA	Digital	IO	
	InputB	Digital	IO	
	Unused	N/A	O	Unused pad
	Unused	N/A	O	Unused pad
GPIO	MCLR	N/A	IO	Active pull-up, 200k resistor to VDD. Pulled low during POR, and MCLR function enabled by default. VPP input for OTP
Digital Out/ I^2C	OutA	Digital	IO	Digital Output / I^2C Data (Debugging)
	OutB	Digital	IO	Digital Output / I^2C Clock (Debugging)
Power	VDD	Power	P	Power supply input voltage
	VREG	Power	P	Internal regulated supply output
	VSS	Power	P	Analog/Digital Ground

[ii] Pin Types: I = Input, O = Output, I/O = Input or Output, P = Power

2.4 Reference Schematic

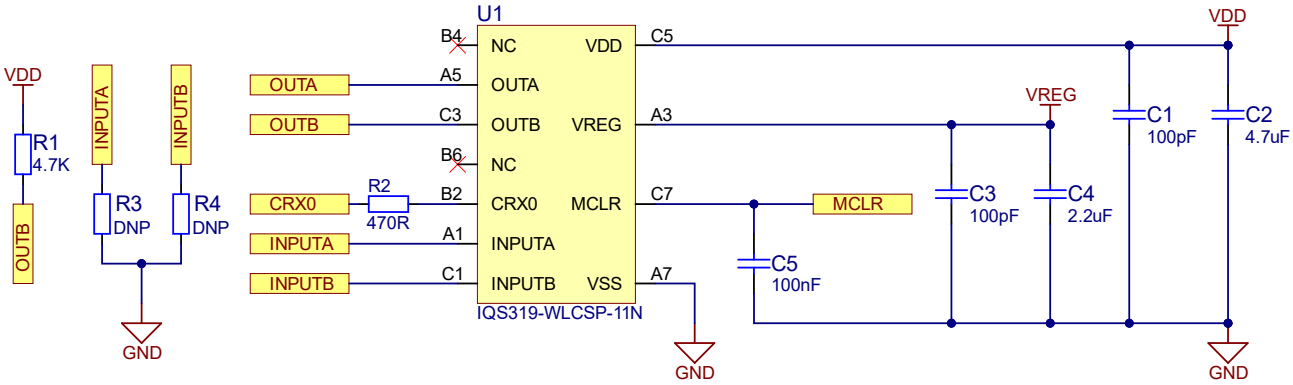


Figure 2.1: WLCSP11 Standalone Reference Schematic [i]

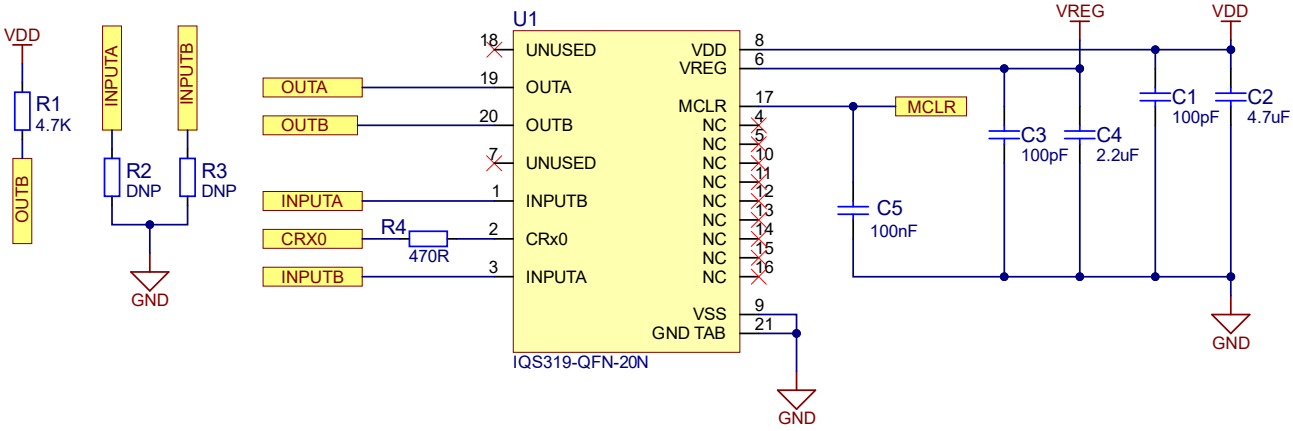


Figure 2.2: QFN20 Standalone Reference Schematic [i]

[ii] For I²C debugging, $4.7k\Omega$ pull-ups are required on OutA, OutB and MCLR

3 Electrical Characteristics

3.1 Absolute Maximum Ratings

	Min	Max	Unit
Voltage applied at VDD pin to VSS	1.71	3.6	V
Voltage applied to any ProxFusion® pin	-0.3	VREG	V
Voltage applied to any other pin (referenced to VSS)	-0.3	VDD + 0.3 (3.6 V max)	V
Storage temperature, T_{stg}	-40	85	°C

3.2 Recommended Operating Conditions

Recommended operating conditions		Min	Nom	Max	Unit
VDD	Supply voltage applied at VDD pin	1.71		3.6	V
VREG	Internal regulated supply output for analog domain		1.53		V
VSS	Supply voltage applied at VSS pin	0	0	0	V
T_A	Operating free-air temperature	–40	25	85	°C
C_{VDD}	Recommended capacitor at VDD	$2\times C_{VREG}$	$3\times C_{VREG}$		µF
C_{VREG}	Recommended external buffer capacitor at VREG, ESR≤ 200 mΩ	2[i]	4.7	13	µF
$Cx_{SELF–VSS}$	Maximum capacitance between ground and external electrodes (self-capacitance mode)			400[ii]	pF
RCx_{SELF}	Series (in-line) resistance of all self-capacitance pins in self-capacitance mode	0[iii]	0.47	10[iv]	kΩ

3.3 ESD Rating

		Value	Unit
$V_{(ESD)}$ Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[v]	± 2000	V

[i] Absolute minimum allowed capacitance value is 1 µF, after taking derating, temperature, and worst-case tolerance into account. Please refer to the AZD004 application note for more information regarding capacitor derating.

[ii] RCx = 0 Ω.

[iii] Nominal series resistance of 470 Ω is recommended to prevent received and emitted EMI effects. Typical resistance also adds additional ESD protection.

[iv] Series resistance limit is a function of f_{xfer} and the circuit time constant, RC. $R_{max} \times C_{max} = \frac{1}{(6\times F_{xfer})}$ where C is the pin capacitance to VSS.

[v] JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Pins listed as ±2000 V may actually have higher performance.

3.4 Current Consumption

Self-capacitive Mode Setup: ATI Target = 2400, F_{xfer} = 250 kHz
Interface Selection: Standalone
VDD Voltage: 3.3 V

Power mode	Active channels	Report rate [ms]	Typical Current [µA]
Default Power Mode	Self-capacitance (1 channel)	40	100

4 Timing and Switching Characteristics

4.1 Reset Levels

Table 4.1: Reset Levels

Parameter		Min	Max	Unit
V_{VDD}	Power-up (Reset trigger) – slope > 100 V/s		1.65	V
	Power-down (Reset trigger) – slope < –100 V/s	0.9		

4.2 MCLR Pin Levels and Characteristics

Table 4.2: MCLR Pin Characteristics

Parameter		Conditions	Min	Typ	Max	Unit
$V_{IL(MCLR)}$	MCLR Input low level voltage	VDD = 3.3 V	VSS – 0.3	-	1.05	V
		VDD = 1.7 V			0.75	
$V_{IH(MCLR)}$	MCLR Input high level voltage	VDD = 3.3 V	2.25	-	VDD + 0.3	V
		VDD = 1.7 V	1.05			
$R_{PU(MCLR)}$	MCLR pull-up equivalent resistor		180	210	240	kΩ
$t_{PULSE(MCLR)}$	MCLR input pulse width – no trigger	VDD = 3.3 V	-	-	15	ns
		VDD = 1.7 V			10	
$t_{TRIG(MCLR)}$	MCLR input pulse width – ensure trigger		250	-	-	ns

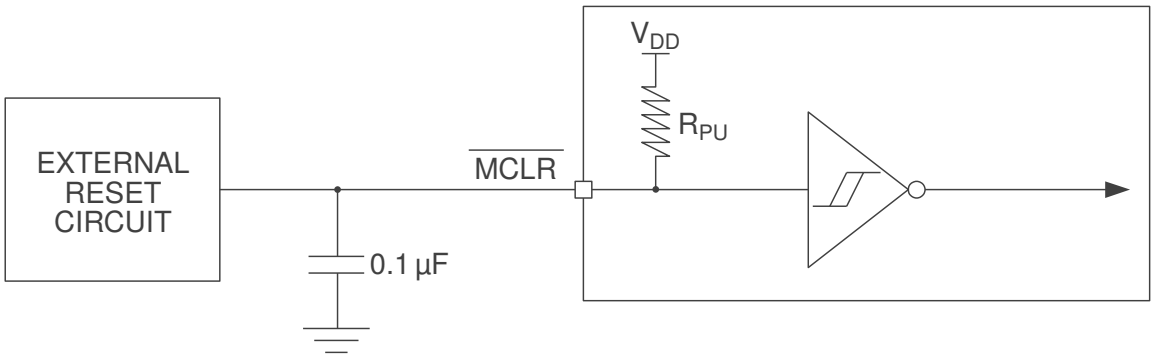


Figure 4.1: MCLR Pin Diagram

4.3 Miscellaneous Timings

Table 4.3: Miscellaneous Timings

Parameter		Min	Typ	Max	Unit
f_{xfer}	Charge transfer frequency (derived from f_{OSC})	55	500-1500	7000	kHz
f_{OSC}	Master CLK frequency tolerance 14 MHz	13.23	14	14.77	MHz

4.4 Digital I/O Characteristics

Table 4.4: Digital I/O Characteristics

Parameter		Test Conditions[i]	Min	Max	Unit
V_{OL}	Output low voltage of SDA and SCL pins	I_{OL} = 20 mA V_{DD} > 2 V		0.4	V
		I_{OL} = 20 mA $V_{DD} \leq$ 2 V		0.2 V_{DD}	
	Output low voltage of SDA and SCL pins in GPIO output mode	I_{OL} = 10 mA		0.1 V_{DD}	
	Output low voltage of MCLR	I_{OL} = 5 mA			
	Output low voltage of any other GPIO pin	I_{OL} = 10 mA			
V_{OH}	Output high voltage	I_{OH} = −5 mA	0.9 V_{DD}		V
V_{IL}	Input low voltage		V_{SS} − 0.3	0.3 V_{DD}	V
V_{IH}	Input high voltage		0.7 V_{DD}	V_{DD} + 0.3	V
C_b	SDA and SCL bus capacitance			550	pF

[i] Standard operating conditions:
V_{DD}: 1.8 V to 3.6 V, unless otherwise stated.
Operating temperature: −20 °C to 80 °C.

4.5 I²C Characteristics

Table 4.5: I²C Characteristics

Parameter		Min	Max	Unit
f_{SCL}	SCL clock frequency		1000	kHz
$t_{HD,STA}$	Hold time (repeated) START	0.26		µs
$t_{SU,STA}$	Setup time for a repeated START	0.26		µs
$t_{HD,DAT}$	Data hold time	0		ns
$t_{SU,DAT}$	Data setup time	50		ns
$t_{SU,STO}$	Setup time for STOP	0.26		µs
t_{BUF}	Bus free time between a STOP and START condition	0.5		µs
t_{SP}	Pulse duration of spikes suppressed by input filter	0	50	ns

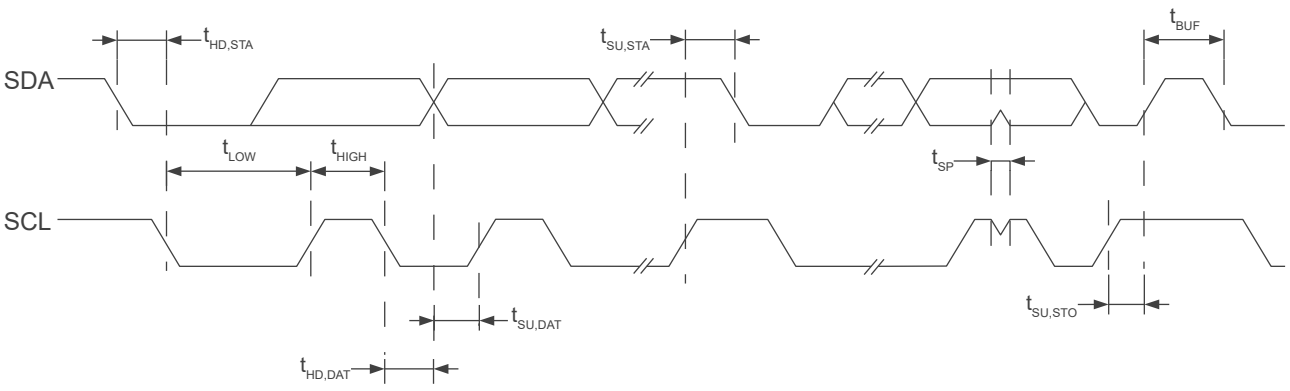


Figure 4.2: I²C Mode Timing Diagram

5 ProxFusion® Module

The IQS319 contains a single ProxFusion® module that uses patented technology to measure and process the sensor data.

5.1 Channel Options

The IQS319 is a single channel self-capacitive sensor intended for SAR and other similar proximity applications.

5.2 Low Power Options

The IQS319 offers a single constant report rate power mode. Order code options give the ability to configure the power mode to obtain the required performance.

5.3 Count Value

The sensing measurement determines a *count value* for the sensing channel. Count values are inversely proportional to capacitive, and all outputs are derived from this.

5.3.1 Max Counts

Each channel is limited to having a count value smaller than the *maximum counts*. If the ATI setting or hardware causes a measured count value higher than this, the conversion will be stopped, and the counts will be limited to the maximum value.

5.4 Reference Value/Long-Term Average (LTA)

User interaction is detected by comparing the measured count values to a reference value known as the *LTA*. The LTA of the sensor is slowly updated to track changes in the environment. During user interaction the LTA is halted.

5.4.1 Reseed

When a reseed event occurs the LTA is seeded with the current counts value. Therefore a reseed event will exit any touch or proximity conditions. The IQS319 automatically handles reseed events.

5.5 Automatic Tuning Implementation (ATI)

The ATI is a sophisticated technology implemented in ProxFusion® devices to allow optimal performance for a wide range of sensing electrode capacitances without modification to external components. For a detailed description of ATI, please contact Azoteq.

5.6 Automatic Re-ATI

5.6.1 Description

A Re-ATI will be triggered if certain conditions are met. One of the most important features of the Re-ATI is that it allows easy and fast recovery from an incorrect ATI, such as when performing ATI during user interaction with the sensor. This could cause the wrong ATI Compensation to be configured, since the user affects the capacitance of the sensor. A Re-ATI would correct this. The IQS319 handles Re-ATI automatically.

5.6.2 ATI Error

After the ATI algorithm is performed, a check is done to see if there was any error with the algorithm. A Re-ATI will be triggered if the following is true:

- Counts are outside the *Re-ATI Boundary* upon completion of the ATI algorithm

The *Re-ATI Boundary* is set by the device and does not require any configuration by the user.

5.7 Sensor Setup

5.7.1 Channel Setup

A single self-capacitive channel sensing on CRx0 is activated on startup. It is designed to detect single level proximity conditions and the channel sensitivity can be adjusted using an input pin on the IQS319. For information on adjusting the channel sensitivity see Section 6.4.2.

5.7.2 Charge Transfer Frequency

The charge transfer frequency (f_{xfer}) is a default of 250 kHz for all order code options unless otherwise indicated.

5.7.3 Filter Betas

An Infinite Impulse Response(IIR) filter is applied to the digitized raw input for both the counts value and the LTA. The filter settings are fixed at startup.

6 Additional Features

6.1 Standalone Power On Sequence

6.1.1 Order Code IQS319001

On startup the IQS319 will follow the sequence shown in Figure 6.1.
The t_{start_up} is typically less than 250 ms.

After t_{start_up} the device performs an ATI. The ATI process typically lasts for 300 ms.

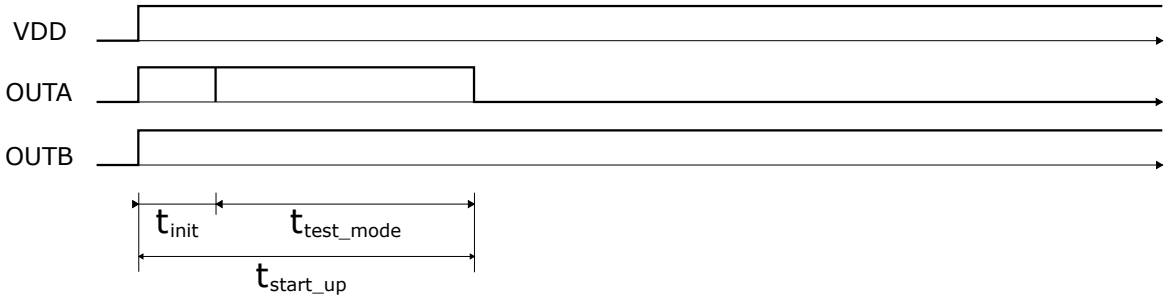


Figure 6.1: Power On Sequence Specification for order code IQS319001

6.1.2 Order Code IQS319002

On startup the IQS319 will follow the sequence shown in Figure 6.2. OutB can be used to determine if the device has started correctly.

Under normal operating conditions OutB should go LOW within 300 ms from power on.
The t_{ATI} is typically 300 ms.

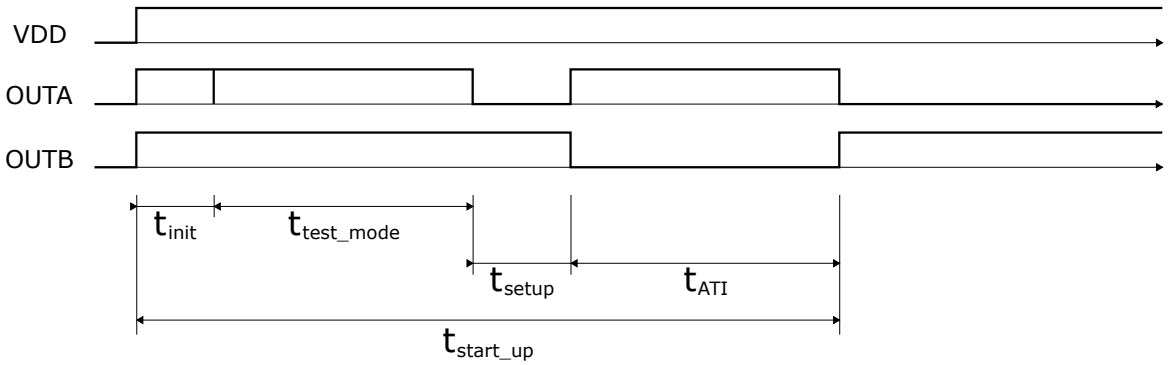


Figure 6.2: Power On Sequence Specification for order code IQS319002

6.2 Debug Mode

On startup, after the device has been initialised, a communication window will be generated where the device can be set to debug mode via I^2C. The duration of this window, t_{test_mode}, is 200 ms and 0x00 should be written to register 0x60 to enter debug mode. Debug mode allows the user to analyse device performance by assessing the device Status, Counts and LTA.

6.3 Output Pin Functionality

OutA and OutB are used to indicate when a touch event has occurred. OutA is configured as a push-pull active high pin and is set to VDD when a touch event is detected. OutB is an open-drain pin configured with active low logic. An external pull-up resistor is required only when using OutB.

6.4 Input Pin Functionality

6.4.1 InputA for Touch Timeout Disable

The touch event timeout can be disabled by connecting InputA to VSS. If InputA is connected to VSS a touch condition will never timeout and the device will remain in touch until the counts are no longer within the touch threshold.

6.4.2 InputB for Sensitivity Adjustment

When InputB is left floating the sensing channel is configured to be less sensitive. Connecting InputB to VSS will increase the sensitivity of the channel.

6.5 Movement UI

The IQS319 implements a Movement User Interface (Movement UI). When a touch condition is entered and no movement is detected on the channel, the channel will reseed after one minute and the touch condition will be exited. The timeout can be disabled using InputA as described in Section 6.4.1. The channel will remain in a touch condition if movement is detected and the delta between the Counts and the LTA is greater than the Touch Threshold.

6.6 Release UI

The IQS319 implements a Release User Interface (Release UI) that allows for the detection and release of long term touch and proximity events. In order to do this, the Release UI makes use of an additional LTA, known as the *Activation LTA*.

When a touch or proximity event is detected the LTA is frozen but the Activation LTA is still updated. When the difference between the Counts and Activation LTA is smaller than the *Activation Settling Threshold* for more than *Delta Snapshot Sample Delay* samples, the counts delta between the LTA and Counts value (*Delta Snapshot*) is recorded.

A percentage of the Delta Snapshot, as defined by *Release Delta Percentage*, is used to exit touch and prox conditions.

If

$$(\text{Counts - Activation LTA}) > (\text{Delta Snapshot} \times \frac{\text{Release Delta Percentage}}{128})$$

the channel is reseeded and therefore any touch or prox conditions are exited.

The Release UI implementation allows for the detection of long term touch events by exiting a touch or prox condition based on the rate at which counts change rather than by comparing the counts to a fixed threshold. It is always enabled on the IQS319 and the relevant parameters are fixed on device startup.

6.7 Watchdog Timer

The IQS319 implements a hardware watchdog timer. The watchdog timer will trigger a software reset if it expires.

6.8 Hardware Reset

The MCLR pin (active LOW) can be used to hard reset the device. For more details see Section 4.2.

7 Memory Map Register Descriptions

These registers can be used to debug the IQS319 in Debug Mode.

Address	Data (16bit)	Notes
0x00 - 0x09	Version details	See Section A.1
Read Only	**System Information**	
0x10	System Status	See Section A.2
0x11	Channel 0 Filtered Counts	16-bit value
0x12	Channel 0 LTA	
0x13	Channel 0 Activation LTA	
0x14	Channel 0 Delta Snapshot	
0x15	Channel 0 Gradient	

8 Ordering Information

8.1 Ordering Code

IQS319 zzz ppb

Table 8.1: Order Code Description

IC NAME			IQS319
DEFAULT CONFIGURATION	zzz	=	001 Single channel proximity sensor (40ms sample rate) 002 Single channel proximity sensor (40ms sample rate, output toggle during ATI)
PACKAGE TYPE	pp	=	CS WLCSP-11 package QF QFN-20 package
BULK PACKAGING	b	=	R WLCSP-11 Reel (3000pcs/reel) QFN20 Reel (2000pcs/reel)

8.2 Top Marking

8.2.1 WLCSP11 Package Marking

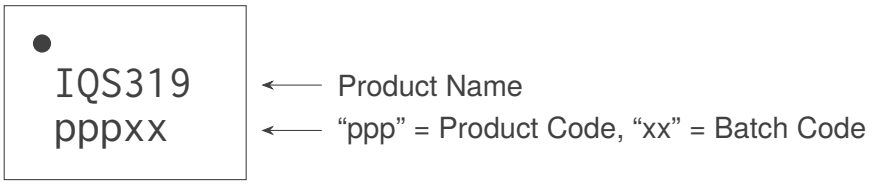


Figure 8.1: IQS319-WLCSP11 Package Top Marking

8.2.2 QFN20 Package Marking Options

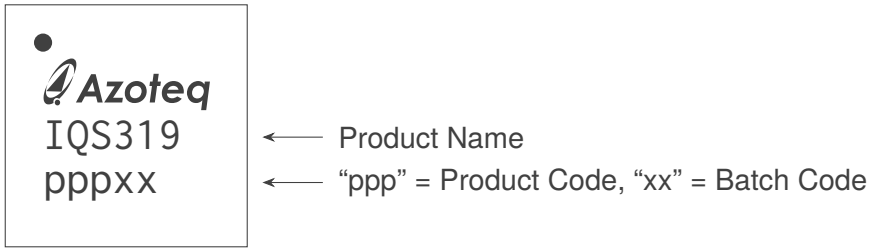


Figure 8.2: IQS319-QFN20 Package Top Marking

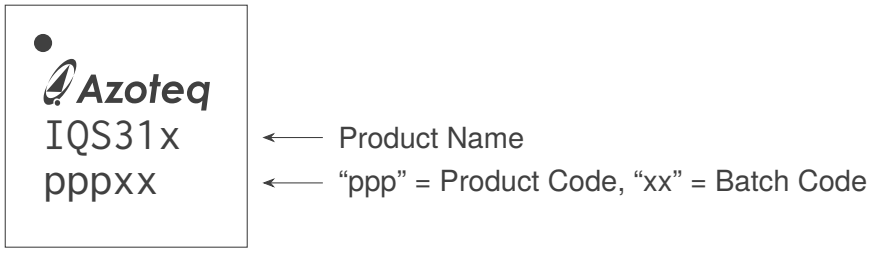


Figure 8.3: IQS31x-QFN20 Package Top Marking

9 Package Specification

9.1 Package Outline Description – WLCSP11

This package outline is specific to order codes ending in WLCSP.

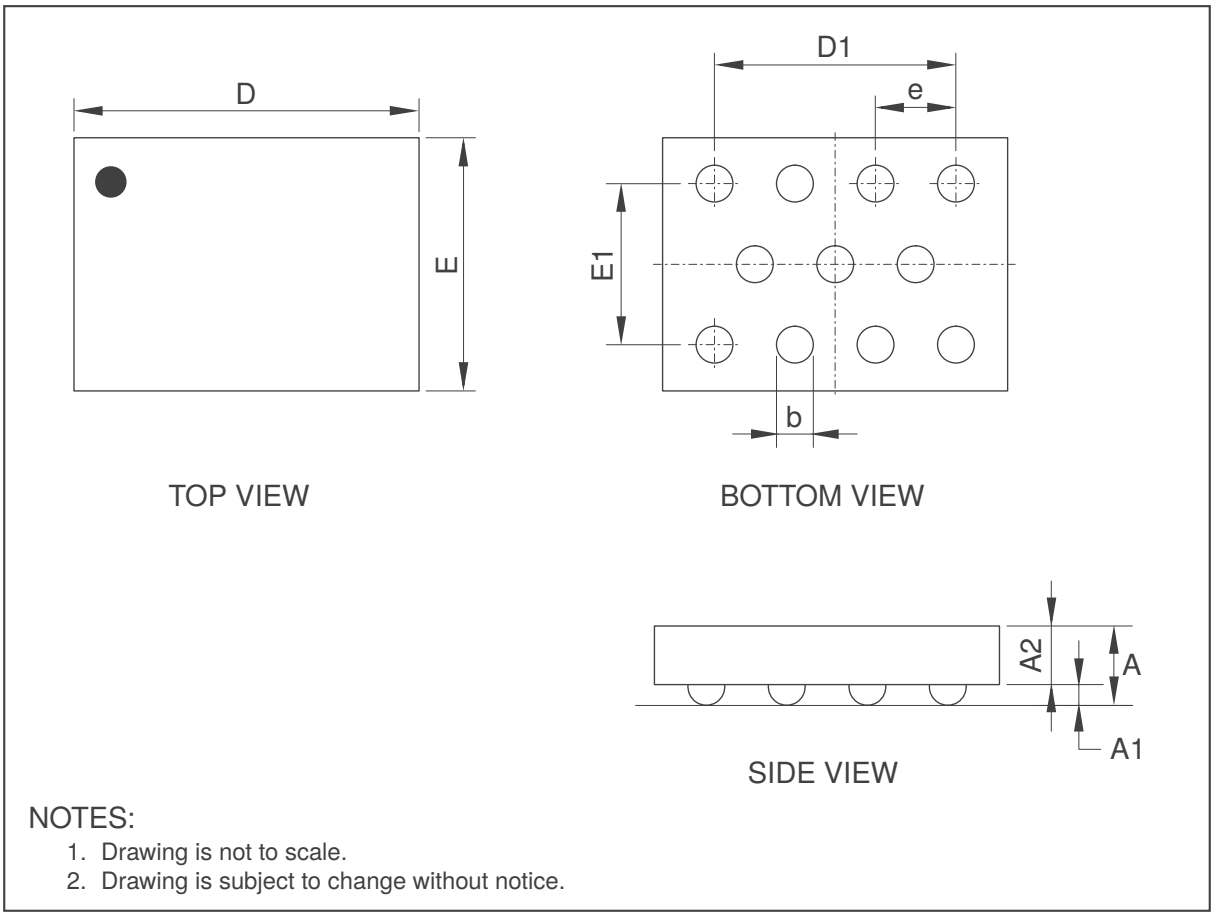
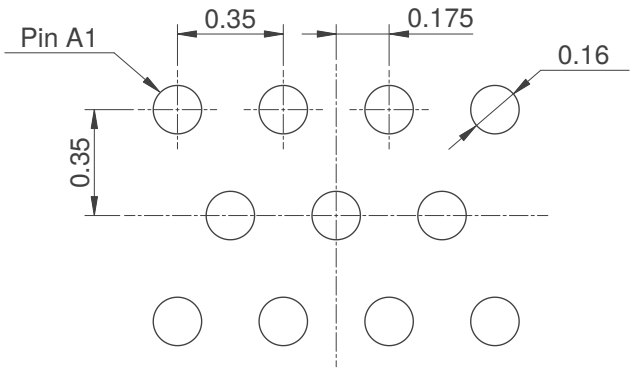


Figure 9.1: WLCSP11 (1.48x1.08) Package Outline Visual Description

Table 9.1: WLCSP11 (1.48x1.08) Package Outline Visual Description (mm)

Dimension	Min	Nom	Max
A	0.303	0.345	0.387
A1	0.076	0.090	0.104
A2	0.227	0.255	0.283
D	1.46	1.48	1.50
E	1.06	1.08	1.10
D1	1.05 BSC		
E1	0.700 BSC		
b	0.136	0.160	0.184
e	0.350 BSC		

9.2 Package Footprint Description – WLCSP11



NOTES:

1. Dimensions are expressed in millimeters.
2. Drawing is not to scale.
3. Drawing is subject to change without notice.
4. Final dimensions may vary due to manufacturing tolerance considerations.

Figure 9.2: WLCSP11 Recommended Footprint

9.3 Package Outline Description – QFN20

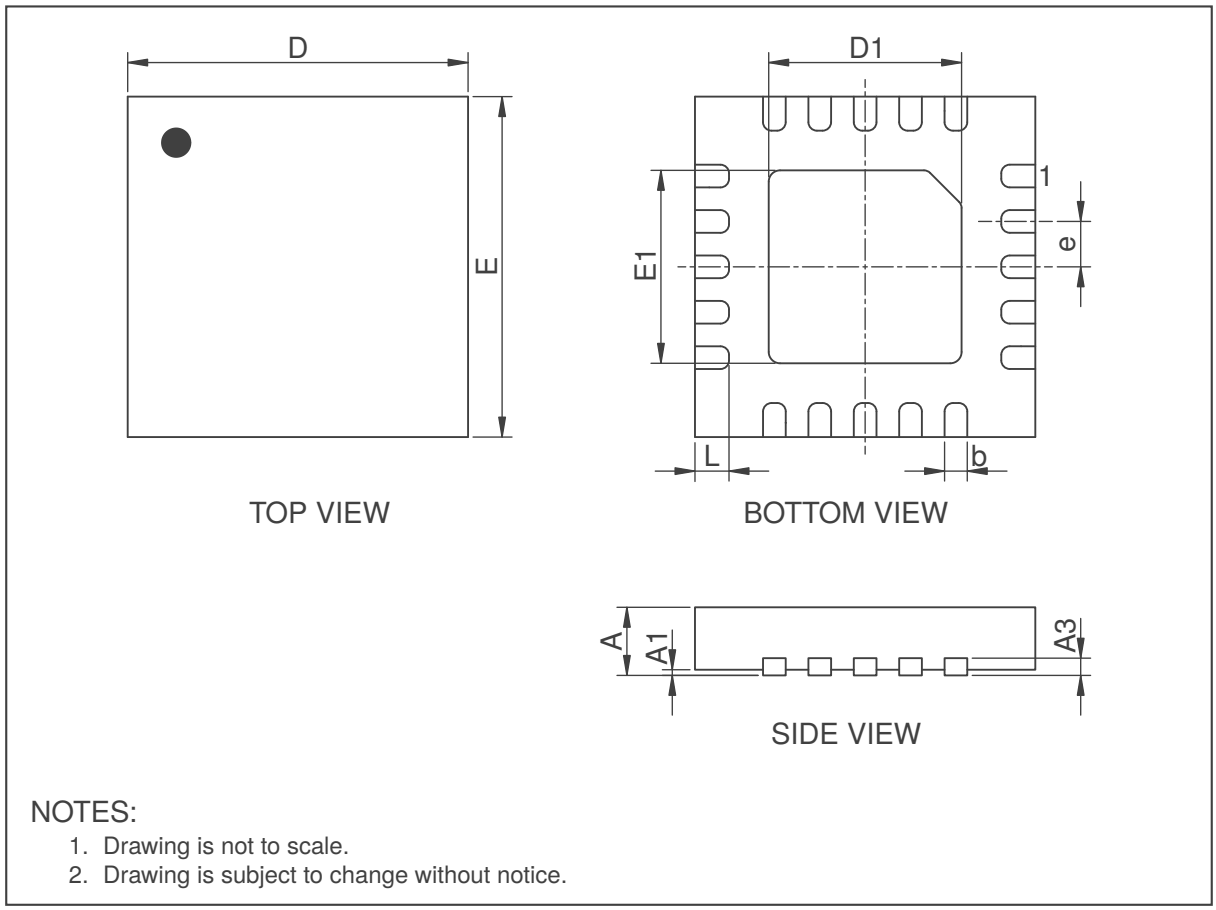
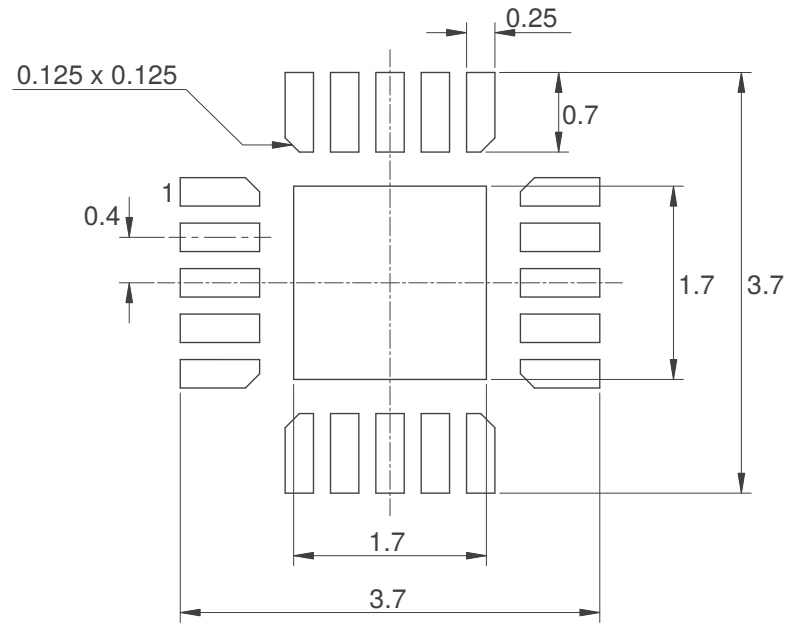


Figure 9.3: QFR (3x3)-20 Package Outline Visual Description

Table 9.2: QFR (3x3)-20 Package Outline Dimensions [mm]

Dimension	Min	Nom	Max
A	0.50	0.55	0.60
A1	0	0.02	0.05
A3		0.152 REF	
b	0.15	0.20	0.25
D	2.95	3.00	3.05
E	2.95	3.00	3.05
D1	1.60	1.70	1.80
E1	1.60	1.70	1.80
e		0.40 BSC	
L	0.25	0.30	0.35

9.4 Package Footprint Description – QFN20

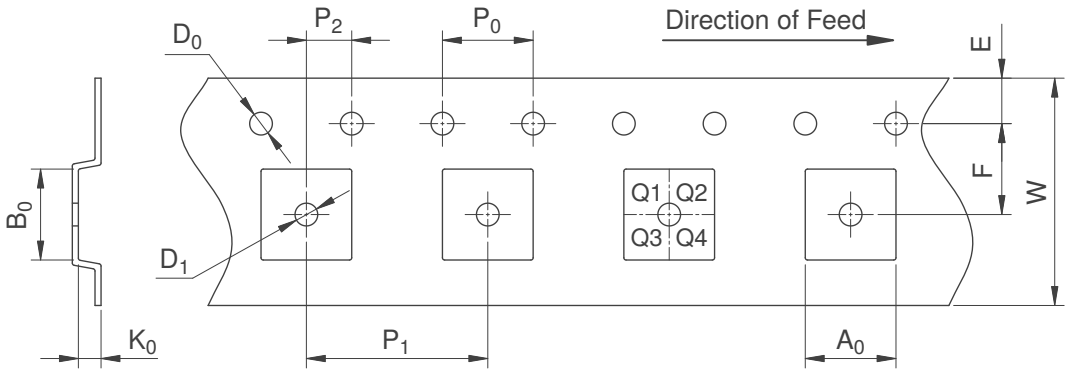


NOTES:

1. Dimensions are expressed in millimeters.
2. Drawing is not to scale.
3. Drawing is subject to change without notice.
4. Final dimensions may vary due to manufacturing tolerance considerations.

Figure 9.4: QFN20 Recommended Footprint

9.5 Tape and Reel Specifications

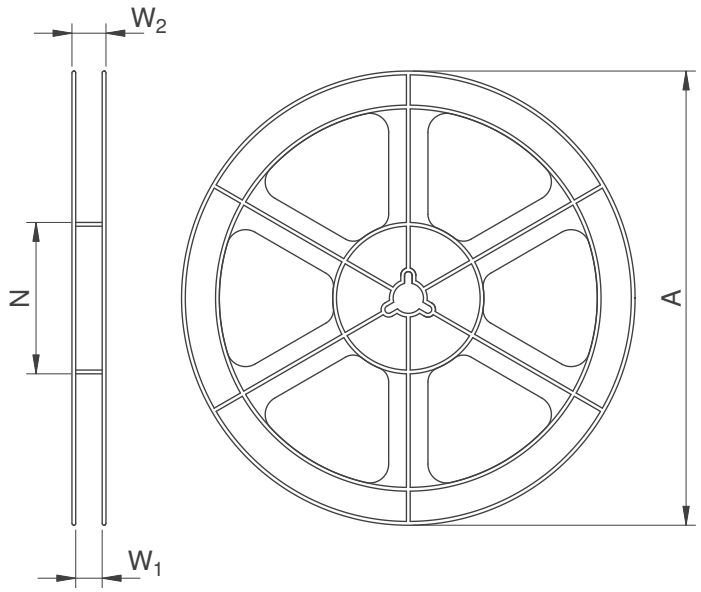


NOTES:
1. Drawing is not to scale.
2. Drawing is subject to change without notice.

Figure 9.5: Carrier Tape Specification

Table 9.3: Carrier Tape Dimensions [mm]

Dimension	Package	
	WLCSP11	QFN20
A_0	1.35	3.30
B_0	1.75	3.30
K_0	0.50	0.75
D_0	1.50	1.50
D_1	0.60	1.55
E	1.75	1.75
F	3.50	5.50
P_0	4.00	4.00
P_1	4.00	8.00
P_2	2.00	2.00
W	8.00	12.00
Pin 1 Quadrant	Q2	Q2



NOTES:
1. Drawing is not to scale.
2. Drawing is subject to change without notice.

Figure 9.6: Reel Specification

Table 9.4: Reel Dimensions [mm]

Dimension	Package	
	WLCSP11	QFN20
A	179	178
N	55	60
W_1	8.4	12.4
W_2 (Max)	14.4	18.4

A Memory Map Descriptions

Note: The value of all Read-write bits marked as Reserved, unless otherwise specified, can be set to 0 or 1 depending on customer's preference.

A.1 Version Information (0x00 – 0x09)

Address	Catergory	Name	Value	Order Code	
0x00	Application Version Info	Product Number	1263		16-bit value
0x01		Major Version	2		
0x02		Minor Version	2	001	
			4	002	
0x03		Patch Number (commit hash)	Reserved		
0x04					
0x05 - 0x09	ROM Library Version Info	Reserved	Reserved		

A.2 System Status (0x11)

Bit	15	14	13	12	11	10	9	8
Description	Reserved	Current Power Mode		Sensitivity	Timeout	Movement	CH0 Touch	CH0 Prox

Bit	7	6	5	4	3	2	1	0
Description	Reset Event	ATI Error	ATI Active	ATI Event	Power Event	Reserved	Touch Event	Prox Event

- Bit 14-13: **Current Power Mode**
  - 00: Normal Power
  - 01: Low Power
- Bit 12: **Sensitivity**
  - 0: Channel setup in normal mode
  - 1: Channel setup in sensitive mode
- Bit 11: **Timeout**
  - 0: No event timeout
  - 1: Event timeout occurred
- Bit 10: **Movement**
  - 0: No movement event
  - 1: Movement event occurred
- Bit 9: **CH0 Touch**
  - 0: CH0 not in Touch
  - 1: CH0 in Touch
- Bit 8: **CH0 Prox**
  - 0: CH0 not in Prox
  - 1: CH0 in Prox
- Bit 7: **Reset Event**
  - 0: No Reset Event occurred
  - 1: Reset Event occurred
- Bit 6: **ATI Error**
  - 0: No ATI Error occurred
  - 1: ATI Error occurred
- Bit 5: **ATI Active**
  - 0: ATI not active
  - 1: ATI active
- Bit 4: **ATI Event**
  - 0: No ATI Event occurred
  - 1: ATI Event occurred

- Bit 3: **Power Event**
  - 0: No Power Event occurred
  - 1: Power Event occurred
- Bit 1: **Touch Event**
  - 0: No Touch Event occurred
  - 1: Touch Event occurred
- Bit 0: **Prox Event**
  - 0: No Prox Event occurred
  - 1: Prox Event occurred

B Revision History

Release	Date	Changes
v1.0	June 2021	Initial release
v1.1	June 2022	Added order code 002 Added order code information Added descriptions for Inputs in Signal Descriptions Table Added Power-on-sequence description Specified time for ATI after Power-on-sequence Small formatting changes and corrections
v1.2	July 2022	Changed Cs Cap description in memory map
v1.3	August 2022	Added tape and reel section
v1.4	August 2022	Added pinout diagrams
v1.5	July 2023	Added Debug Mode section Updated version information Updated memory map to only indicate debugging registers
v1.6	August 2024	Added QFN20 option Fixed DFN12 top marking Updated VREG minimum capacitance footnote
v1.7	September 2024	Updated memory map style Updated the documentations layout and format
v1.8	February 2025	Updated Order Code section
v1.9	July 2026	Removed DFN12 Package information

Contact Information

	South Africa (Headquarters)	China
Physical Address	1 Bergsig Avenue Paarl 7646 South Africa	Room 501A, Block A T-Share International Centre Taoyuan Road, Nanshan District Shenzhen, Guangdong, PRC
Tel	+27 21 863 0033	+86 755 8303 5294 ext 808
Email	info@azoteq.com	info@azoteq.com

	USA	Taiwan
Physical Address	7000 North Mopac Expressway Suite 200 Austin TX 78731 USA	Xintai 5th Road, Sec. 1 No. 99, 9F-12C Xizhi District 221416 New Taipei City Taiwan
Tel	+1 512 538 1995	+886 932 219 444
Email	info@azoteq.com	info@azoteq.com

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

Patents as listed on www.azoteq.com/patents-trademarks/ may relate to the device or usage of the device.