WIRELESS & SENSING

GENERAL DESCRIPTION

The SX9310 is a capacitive Specific Absorption Rate (SAR) controller.

The SX9310 can use two of the three sensor inputs coupled to its smart engine for SAR to accurately discriminate between an inanimate object and human body. The third sensor input can be used independently for standard capacitive sensing.

The resulting detection is used in portable electronic devices to reduce and control radio-frequency (RF) emission power in the presence of a human body, enabling significant performance advantages for manufacturers of electronic devices with electro-magnetic radiation sources to meet stringent emission regulations' criteria and Specific Absorption Rate (SAR) standards.

The SX9310 operates directly from an input supply voltage of 2.7 to 5.5V, while the I2C serial communication bus port is compatible with 1.8V host control to report body detection/proximity and to facilitate parameter settings adjustment. Upon proximity detection, the NIRQ output asserts, enabling the user to either determine the relative proximity distance, or simply obtain an indication of detection.

The SX9310 includes an on-chip auto-calibration controller that regularly performs sensitivity adjustments to maintain peak performance over a wide variation of temperature, humidity and noise environments, providing simplified product development and enhanced performance.

KEY PRODUCT FEATURES

- **2.7 – 5.5V Core Supply (VDD)**
  - 1.65 – 2V Host Interface Supply (SVDD)
  - 1.65 – 5.5V Compliant Host Interface (VPULL)
- **Up to 3 SAR Capacitive Sensor Inputs**
  - Patented On-Chip Smart Engine For SAR (Body versus Inanimate Object Detection)
  - Capacitance Resolution down to 0.08 fF
  - Capacitance Offset Compensation up to 100 pF
  - Integrated RF Shield
  - Advanced Temperature Compensation
- **Automatic Calibration**
- **Built-in Start-up Proximity Detection**
- **Ultra Low Power Consumption**
  - Active Mode: 70 uA
  - Doze Mode: 8 uA
  - Sleep Mode: 2.5 uA
- **400kHz I2C Serial Interface**
- **Programmable Interrupt or Real-Time Status Pin**
- **User NVM for Custom Default Registers Values (Standalone Mode)**
- **Two Reset Sources: POR, Soft Reset**
- **-40°C to +85°C Operation**
- **Compact Size: 1.36 x 1.33 mm WLCSP package**
- **Pb & Halogen Free, RoHS/WEEE compliant**

APPLICATIONS

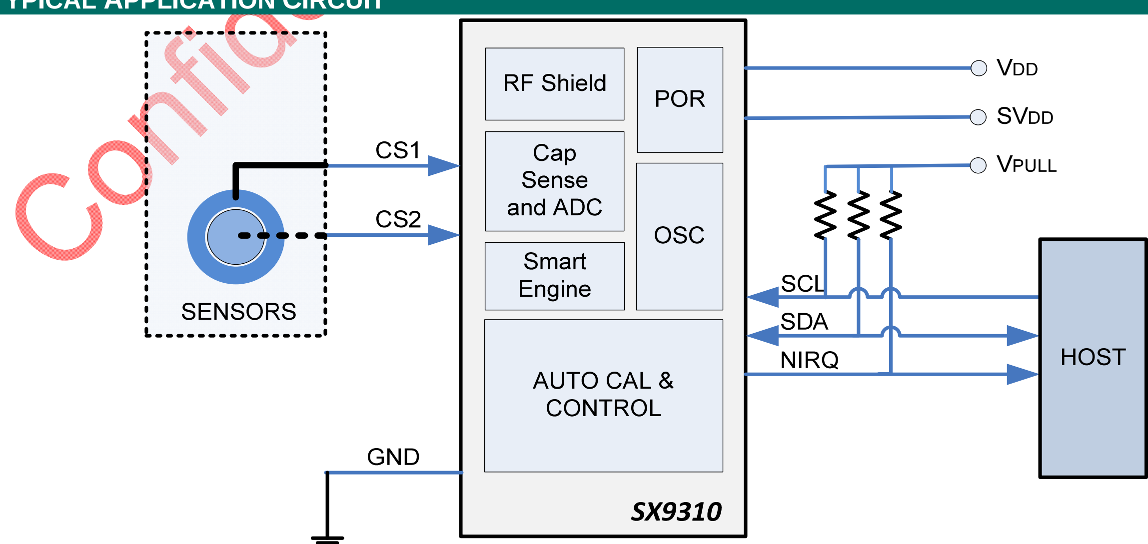
- SAR Compliant Systems
- Notebooks
- Tablets
- Mobile Phones
- Mobile Hot Spots

ORDERING INFORMATION

Part Number	Package	Marking
SX9310ICSTRT[1]	WLCSP-9	MO8B
SX9310EVKA	Eval. Kit	-

[1] 3000 Units/reel

TYPICAL APPLICATION CIRCUIT



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1 GENERAL DESCRIPTION

1.1 Pin Diagram

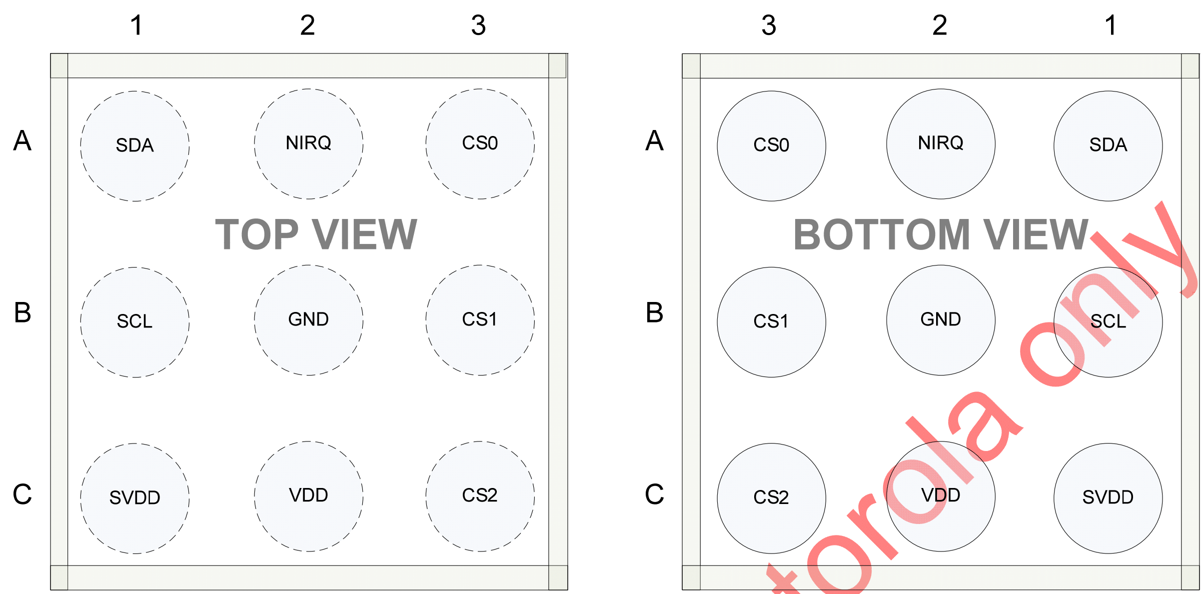


Figure 1: Pin Diagram

1.2 Marking Information

yyww= Date Code

Figure 2: Marking Information

1.3 Pin Description

Number	Name	Type	Description
C3	CS2	Analog	Capacitive Sensor Input
B3	CS1	Analog	Capacitive Sensor Input
A3	CS0	Analog	Capacitive Sensor Input (or Shield/CSG if unused)
C2	V_{DD}	Power	Main power supply
C1	SV_{DD}	Power	Host interface power supply
A2	NIRQ	Digital Output	Interrupt or Real-time Status pin, may require pull-up resistor
B1	SCL	Digital Input	I2C Clock, requires pull-up resistor
A1	SDA	Digital Input/Output	I2C Data, requires pull-up resistor
B2	GND	Ground	Ground

Table 1: Pin Description

1.4 Acronyms

SAR Specific Absorption Rate
RF Radio Frequency

2 ELECTRICAL CHARACTERISTICS

2.1 Absolute Maximum Ratings

Stresses above the values listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these, or any other conditions beyond the "Operating Conditions", is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability and proper functionality.

Parameter	Symbol	Min	Max	Unit
Supply Voltage	V_{DD}	-0.5	6	V
	SV_{DD}	-0.5	2.4	
Pull-up Voltage	V_{PULL}	-0.5	6	
Input Voltage (non-supply pins)	V_{IN}	-0.5	V_{DD}+0.3	
Input Current (non-supply pins)	I_{IN}	-10	10	mA
Operating Junction Temperature	T_{JCT}	-40	125	°C
Reflow Temperature	T_{RE}	-	260	
Storage Temperature	T_{STOR}	-50	150	
ESD HBM (ANSI/ESDA/JEDEC JS-001)	ESD_{HBM}	3.5	-	kV

Table 2: Absolute Maximum Ratings

2.2 Operating Conditions

Parameter	Symbol	Min	Max	Unit
Supply Voltage	V_{DD}	2.7	5.5	V
	SV_{DD}	1.65	2	
Pull-up Voltage	V_{PULL}	-*	5.5	V
Ambient Temperature	T_A	-40	85	°C

Table 3: Operating Conditions

* No minimum on NIRQ; for SCL and SDA please refer to V_{IH} specification.

Note: SVDD, VDD and VPULL are fully independent, i.e. can be turned ON/OFF separately and in any sequence without creating any leakage current.

2.3 Thermal Characteristics

Parameter	Symbol	Typical	Unit
Thermal Resistance – Junction to Air (Static Airflow)	θ_{JA}	120	°C/W

Table 4: Thermal Characteristics

Note: θ_{JA} is calculated from a package in still air, mounted to 3" x 4.5", 4-layer FR4 PCB per JESD51 standards.

2.4 Electrical Specifications

All values are valid within the operating conditions unless otherwise specified.
Typical values are given for T_A= +25°C, VDD=3V, SVDD=1.8V unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Current Consumption						
Sleep (no sensor enabled)	I_{VDD_SLEEP}	Power down, all analog circuits shut down. SENSOREN = 0000	-	2.5	5	uA
Doze	I_{VDD_DOZE}	SCANPERIOD = 30x16 = 480ms FREQ = 166.7kHz RESOLUTION = Fine SENSOREN = 0001	-	8	15	
Active	I_{VDD_ACTIVE}	SCANPERIOD = 30ms FREQ = 166.7kHz RESOLUTION = Fine SENSOREN = 0001	-	70	115	
Host Interface	I_{SVDD}	After power-up, I2C listening.	-	0.05	1.3	
Outputs: SDA, NIRQ						
Output Low Current	I_{OL04}	VOL ≤ 0.32V	3	-	-	mA
	I_{OL06}	VOL ≤ 0.6V	6	-	-	
Output High Current (NIRQ in push-pull mode)	I_{OH}	VOH ≥ 0.8 x SV_{DD}	3	-	-	
Inputs: SCL, SDA						
Input High Voltage	V_{IH}		0.7 x SV_{DD}	-	5.5	V
Input Low Voltage	V_{IL}		-0.5	-	0.3 x SV_{DD}	
Input Leakage Current	I_L	CMOS input	-1	-	1	uA
Hysteresis	V_{HYS}		0.05 x SV_{DD}	-	-	V
Miscellaneous						
Power-up Time	T_{POR}		-	-	1	ms
External DC Capacitance to Ground per Sensor(s) Measurement/Channel	C_{DC0}	CS0, COMB with CS0 (CSOFF=00)	-	-	90	pF
	C_{DC12}	CS1, CS2, COMB without CS0	-	-	100	

Table 5: Electrical Specifications

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
I2C Timing Specifications (Cf. Figure 3 and Figure 4 below)						
SCL clock frequency	f_{SCL}		-	-	400	kHz
SCL low period	t_{LOW}		1.3	-	-	
SCL high period	t_{HIGH}		0.6	-	-	
Data setup time	$t_{SU;DAT}$		0.1	-	-	
Data hold time	$t_{HD;DAT}$		0	-	-	
Repeated start setup time	$t_{SU;STA}$		0.6	-	-	us
Start condition hold time	$t_{HD;STA}$		0.6	-	-	
Stop condition setup time	$t_{SU;STO}$		0.6	-	-	
Bus free time between stop and start	t_{BUF}		1.3	-	-	
Data valid time	$t_{VD;DAT}$		-	-	0.9	
Data valid acknowledge time	$t_{VD;ACK}$		-	-	0.9	
Input glitch suppression	t_{SP}	Note 1	-	-	50	ns

Note 1: Minimum glitch amplitude is $0.7V_{DD}$ at High level and Maximum $0.3V_{DD}$ at Low level.

Table 6: I2C Timing Specifications

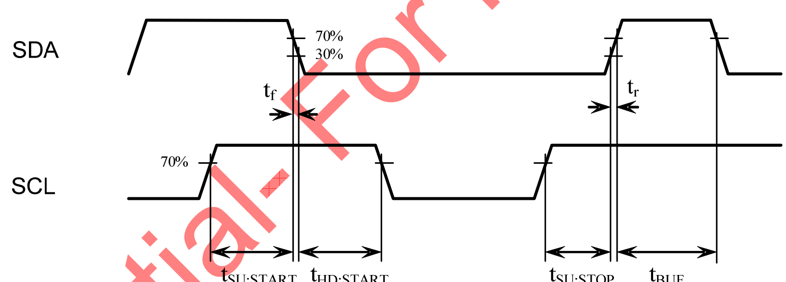


Figure 3: I2C Start and Stop Timing

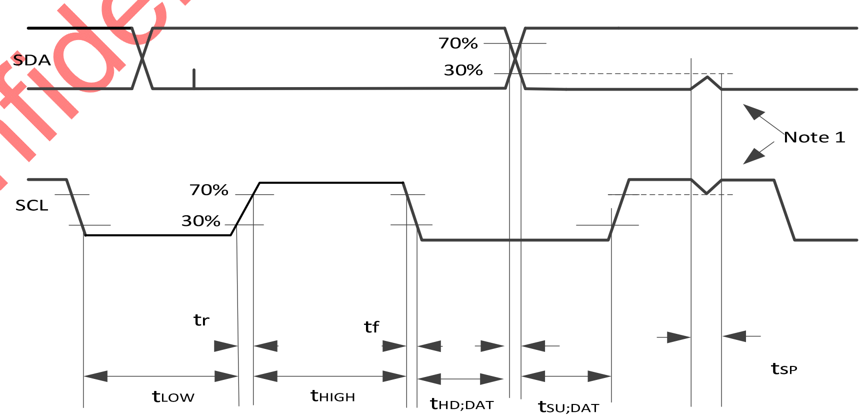


Figure 4: I2C Data Timing

3 PROXIMITY SENSING INTERFACE

3.1 Introduction

The purpose of the proximity sensing interface is to detect when a conductive object (usually a body part i.e. finger, palm, face, etc) is in the proximity of the system. Note that proximity sensing can be done through the air or through a solid (typically plastic) overlay (also called “touch” sensing).

The chip’s proximity sensing interface is based on capacitive sensing technology. An overview is given the in figure below.

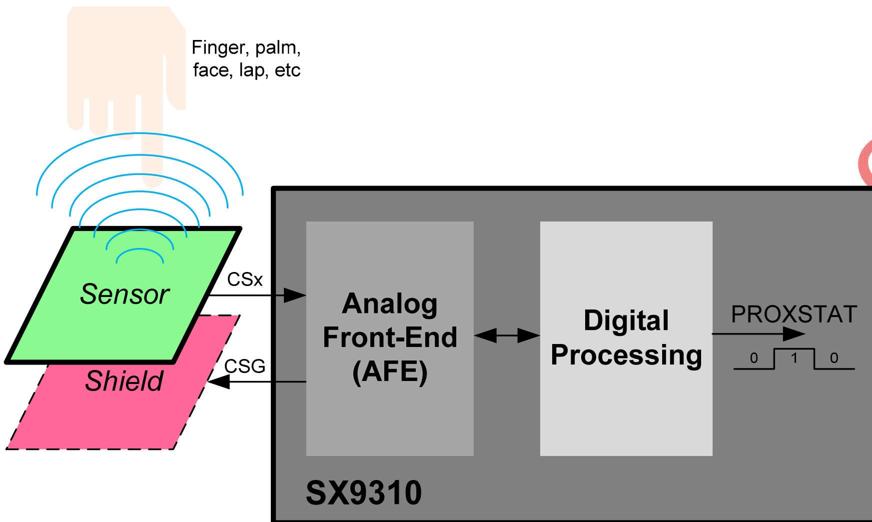


Figure 5: Proximity Sensing Interface Overview

- The sensor can be a simple copper area on a PCB or FPC for example. Its capacitance (to ground) will vary when a conductive object is moving in its proximity.
- The optional shield can also be a simple copper area on a PCB or FPC below/under/around the sensor. It is used to protect the sensor against potential surrounding noise sources and improve its global performance. It also brings directivity to the sensing, for example sensing objects approaching from top only. When disabled, CS0 is used for shield/CSG.
- The analog front-end (AFE) performs the raw sensor’s capacitance measurement and converts it into a digital value. It also controls the shield. See §3.3 for more details.
- The digital processing block computes the raw capacitance measurement from the AFE and extracts a binary information PROXSTAT corresponding to the proximity status, i.e. object is “Far” or “Close”. It also triggers AFE operations (compensation, etc). See §3.4 for more details.

3.2 Scan Period

To save power and since the proximity event is slow by nature, the chip will awake regularly at every programmed scan period (SCANPERIOD) to first sense sequentially each of the enabled CSx pins and then process new proximity samples/info. The chip will be in idle mode most of the time. This is illustrated in figure below

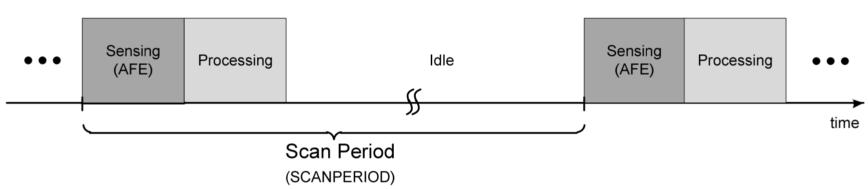


Figure 6: Proximity Sensing Sequencing

The sensing and processing phase’s durations vary with the number of sensors enabled, the sampling frequency, and the resolution programmed. During the Idle phase, the chip‘s analog circuits are turned off. Upon expiry of the idle timer, a new scan period cycle begins.

The scan period determines the minimum reaction time (actual/final reaction time also depends on debounce and filtering settings) and can be programmed from typ. 15ms to 5s.

3.3 Analog Front-End (AFE)

3.3.1 Capacitive Sensing Basics

Capacitive sensing is the art of measuring a small variation of capacitance in a noisy environment. As mentioned above, the chip's proximity sensing interface is based on capacitive sensing technology. In order to illustrate some of the user choices and compromises required when using this technology it is useful to understand its basic principles.

To illustrate the principle of capacitive sensing we will use the simplest implementation where the sensor is a copper plate on a PCB.

The figure below shows a cross-section and top view of a typical capacitive sensing implementation. The sensor connected to the chip is a simple copper area on top layer of the PCB. It is usually surrounded (shielded) by ground for noise immunity (shield function) but also indirectly couples via the ground areas of the rest of the system (PCB ground traces/planes, housing, etc). For obvious reasons (design, isolation, robustness …) the sensor is stacked behind an overlay which is usually integrated in the housing of the complete system.

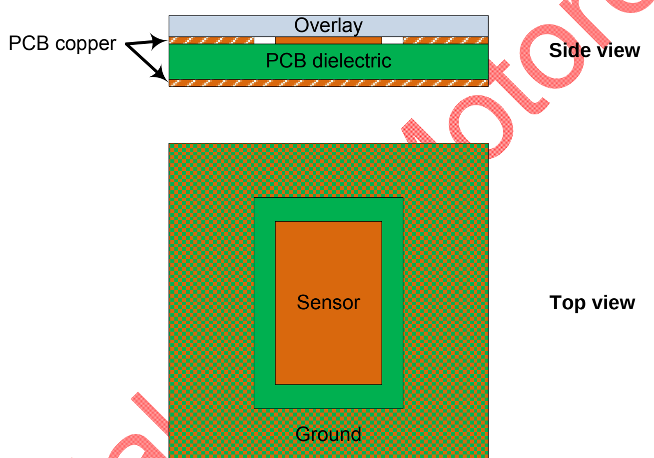


Figure 7: Typical Capacitive Sensing Implementation

When the conductive object to be detected (finger/palm/face, etc) is not present, the sensor only sees an inherent capacitance value C_{Env} created by its electrical field's interaction with the environment, in particular with ground areas.

When the conductive object (finger/palm/face, etc) approaches, the electrical field around the sensor will be modified and the total capacitance seen by the sensor increased by the user capacitance C_{User}. This phenomenon is illustrated in the figure below.

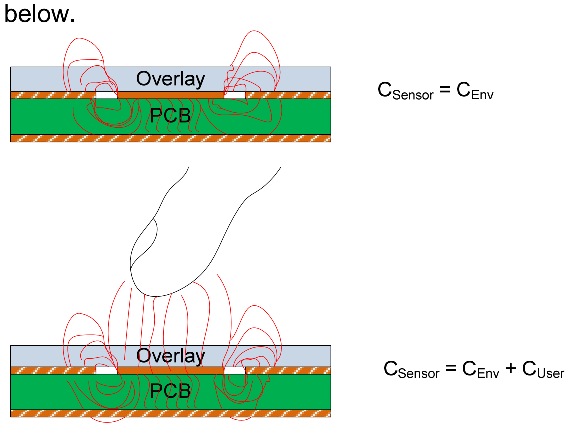


Figure 8: Proximity Effect on Electrical Field and Sensor Capacitance

The challenge of capacitive sensing is to detect this relatively small variation of C_{Sensor} (C_{User} usually contributes for a few percent only) and differentiate it from environmental noise (C_{Env} also slowly varies together with the environment characteristics like temperature, etc). For this purpose, the chip integrates an auto offset compensation mechanism which dynamically monitors and removes the C_{Env} component to extract and process C_{User} only. See §3.3.5 for more details.

In first order, C_{User} can be estimated by the formula below:

$$\boxed{C_{User} = \frac{\varepsilon_0 \cdot \varepsilon_r \cdot A}{d}}$$

A is the common area between the two electrodes hence the common area between the user's finger/palm/face and the sensor.

d is the distance between the two electrodes hence the proximity distance between the user and the system.

ε_0 is the free space permittivity and is equal to 8.85 10e-12 F/m (constant)

ε_r is the dielectric relative permittivity.

Typical permittivity of some common materials is given in the table below.

Material	Typical ε_r
Glass	8
FR4	5
Acrylic Glass	3
Wood	2
Air	**1**

Table 7: Typical Permittivity of Some Common Materials

From the discussions above we can conclude that the most robust and efficient design will be the one that minimizes C_{Env} value and variations while improving C_{User}.

3.3.2 AFE Block Diagram

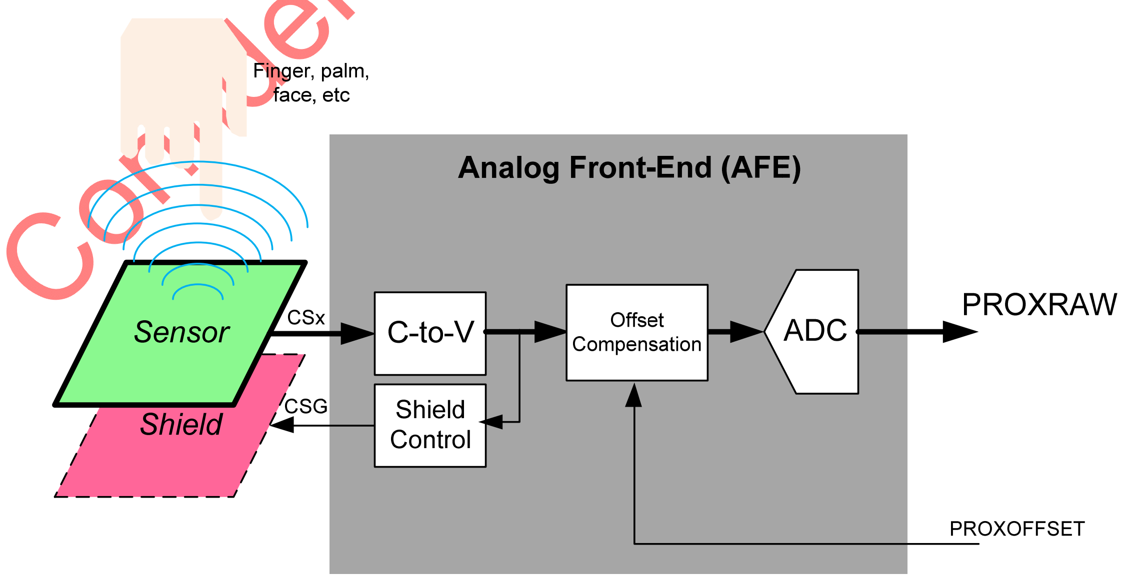


Figure 9: Analog Front-End Block Diagram

3.3.3 Capacitance-to-Voltage Conversion (C-to-V)

The sensitivity of the interface is determined by RANGE and GAIN parameters.

FREQ defines the operating frequency of the interface and should be set as high as possible for power consumption reasons.

3.3.4 Shield Control

When disabled, CS0 is used for shield/CSG.

3.3.5 Offset Compensation

Offset compensation consists of performing a one-time measurement of C_{Env} and subtracting from the total capacitance C_{Sensor} in order to feed the ADC with the closest contribution of C_{User} only.

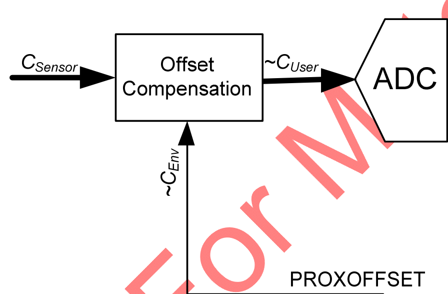


Figure 10: Offset Compensation Block Diagram

The ADC input C_{User} is the total capacitance C_{Sensor} to which C_{Env} is subtracted.

There are three possible compensation sources which are illustrated in the figure below. When set to 1 by any of these sources, COMPSTAT will only be reset once the compensation is completed.

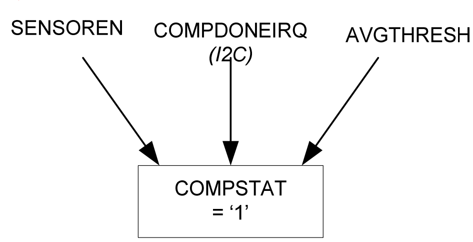


Figure 11: Compensation Request Sources

- SENSOREN: a compensation is automatically requested for a sensor on the rising edge of its SENSOREN bit.
- COMPDONEIRQ (I2C): a compensation for all sensors can be manually requested anytime by the host through I2C interface by writing a 1 into COMPDONEIRQ.
- AVGTHRESH: a compensation for the relevant sensor only, can be automatically requested if it is detected that C_{Env} has drifted beyond a predefined range programmed by the host.

Please note that the compensation request flag can be set anytime but the compensation itself is always done at the beginning of a scan period to keep all parameters coherent.
Also, when compensation occurs, all compensated sensors' PROXSTAT flags turn OFF (i.e. no proximity detected) independently from the user's potential actual presence (except if start-up detection is enabled).

3.3.6 Analog-to-Digital Conversion (ADC)

An ADC is used to convert the analog capacitance information into a digital word PROXRAW.

3.4 Digital Processing

3.4.1 Overview

The main purpose of the digital processing block is to convert the raw capacitance information coming from the AFE (PROXRAW) into a robust and reliable digital flag (PROXSTAT) indicating if something is within range of the proximity sensor.

The offset compensation performed in the AFE is a one-time measurement. However, the environment capacitance C_{Env} may vary with time (temperature, nearby objects, etc). Hence, in order to get the best estimation of C_{User} (PROXDIFF), the digital processing block dynamically tracks and subtracts C_{Env} variations. This is performed by filtering PROXUSEFUL to extract its slow variations (PROXAVG).

PROXDIFF is then compared to user programmable threshold (PROXTHRESH) to extract PROXSTAT flag.

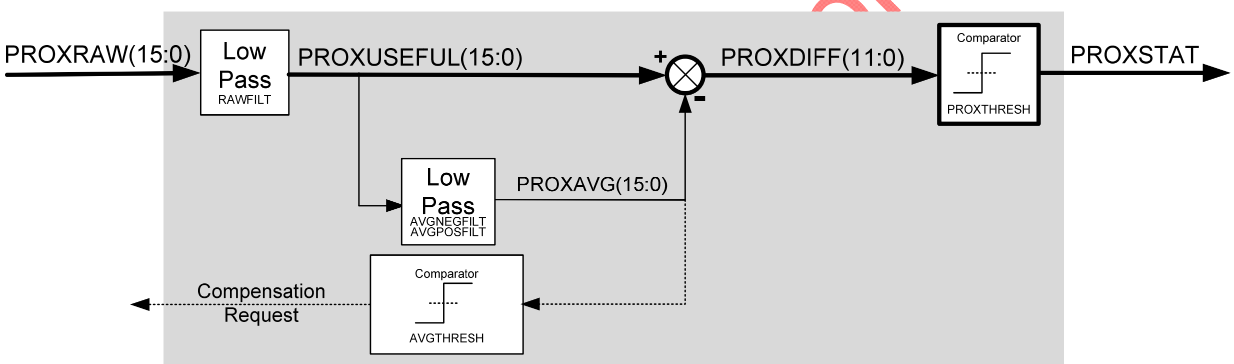


Figure 12: Digital Processing Block Diagram

The digital processor sequence (for all enabled channels) is illustrated in figure below. At every scan period wake-up, the block updates sequentially PROXRAW, PROXUSEFUL, PROXAVG, PROXDIFF and PROXSTAT before going back to Idle mode.

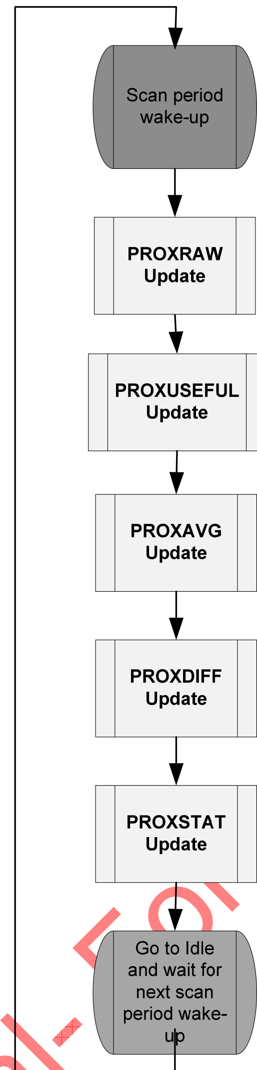


Figure 13: Digital Processor Sequence

The digital processing block also updates COMPSTAT (set when compensation is currently pending execution or completion).

3.4.2 PROXRAW Update

PROXRAW update consists mainly of starting the AFE and waiting for the new PROXRAW values (one for each CSx/sensor pin) to be ready. If compensation was pending it is performed first.

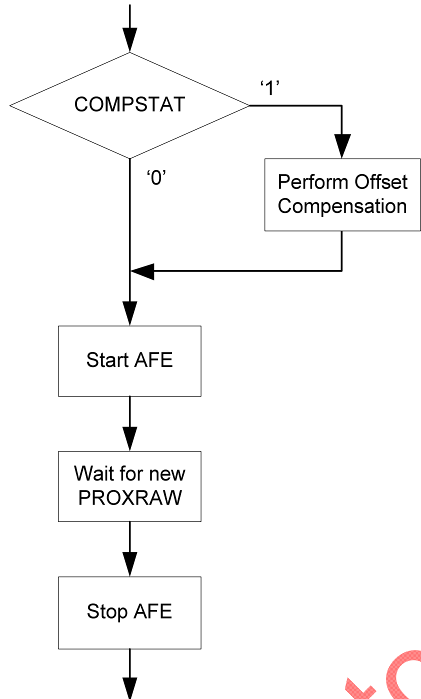


Figure 14: ProxRaw Update

Note that PROXRAW is not available in the "Sensor Data Readback" section of the registers. If needed it can be observed by setting RAWFILT=00 and reading PROXUSEFUL.

3.4.3 PROXUSEFUL Update

PROXUSEFUL update consists of filtering PROXRAW upfront to remove its high frequencies components (system noise, interferer, etc) and extract only user activity (few Hz max) and slow environment changes.

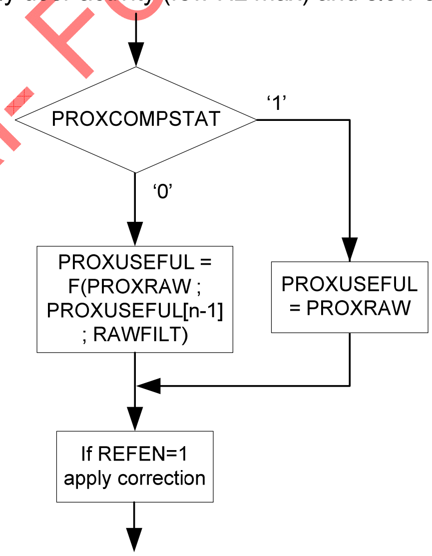


Figure 15: PROXUSEFUL Update

F(PROXRAW ; PROXUSEFUL[n-1] ; RAWFILT) = (1 - RAWFILT).PROXRAW + RAWFILT.PROXUSEFUL[n-1]

3.4.4 PROXAVG Update

PROXAVG update consists of averaging PROXUSEFUL to ignore its "fast" variations (i.e. user finger/palm/hand) and extract only the very slow variations of environment capacitance C_{Env}.

One can program a debounced threshold (AVGTHRESH/AVGDEB) to define a range within which PROXAVG can vary without triggering compensation (i.e. small acceptable environment drift).

Large positive values of PROXUSEFUL are considered as normal (user finger/hand/head) but large negative values are considered abnormal and should be compensated quickly. For this purpose, the averaging filter coefficient can be set independently for positive and negative variations via AVGPOSFILT and AVGNEGFILT. Typically, AVGPOSFILT > AVGNEGFILT to filter out (abnormal) negative events faster.

To prevent PROXAVG from being "corrupted" by user activity (it should only reflect environmental changes) it is frozen when proximity is detected.

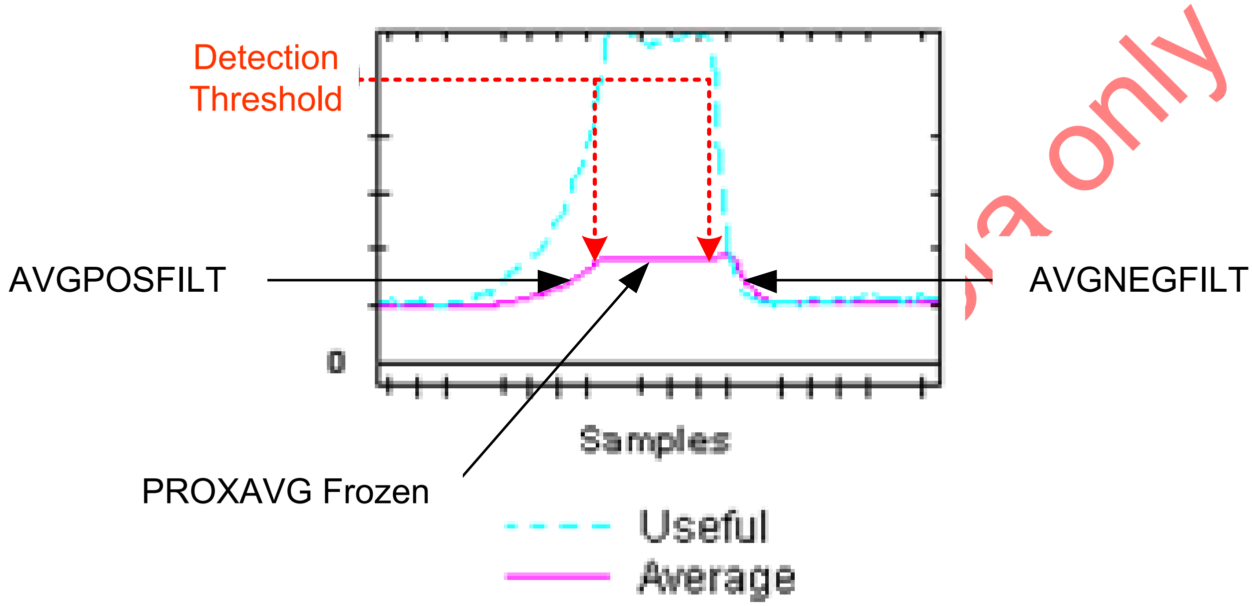


Figure 16: ProxAvg vs Proximity Event

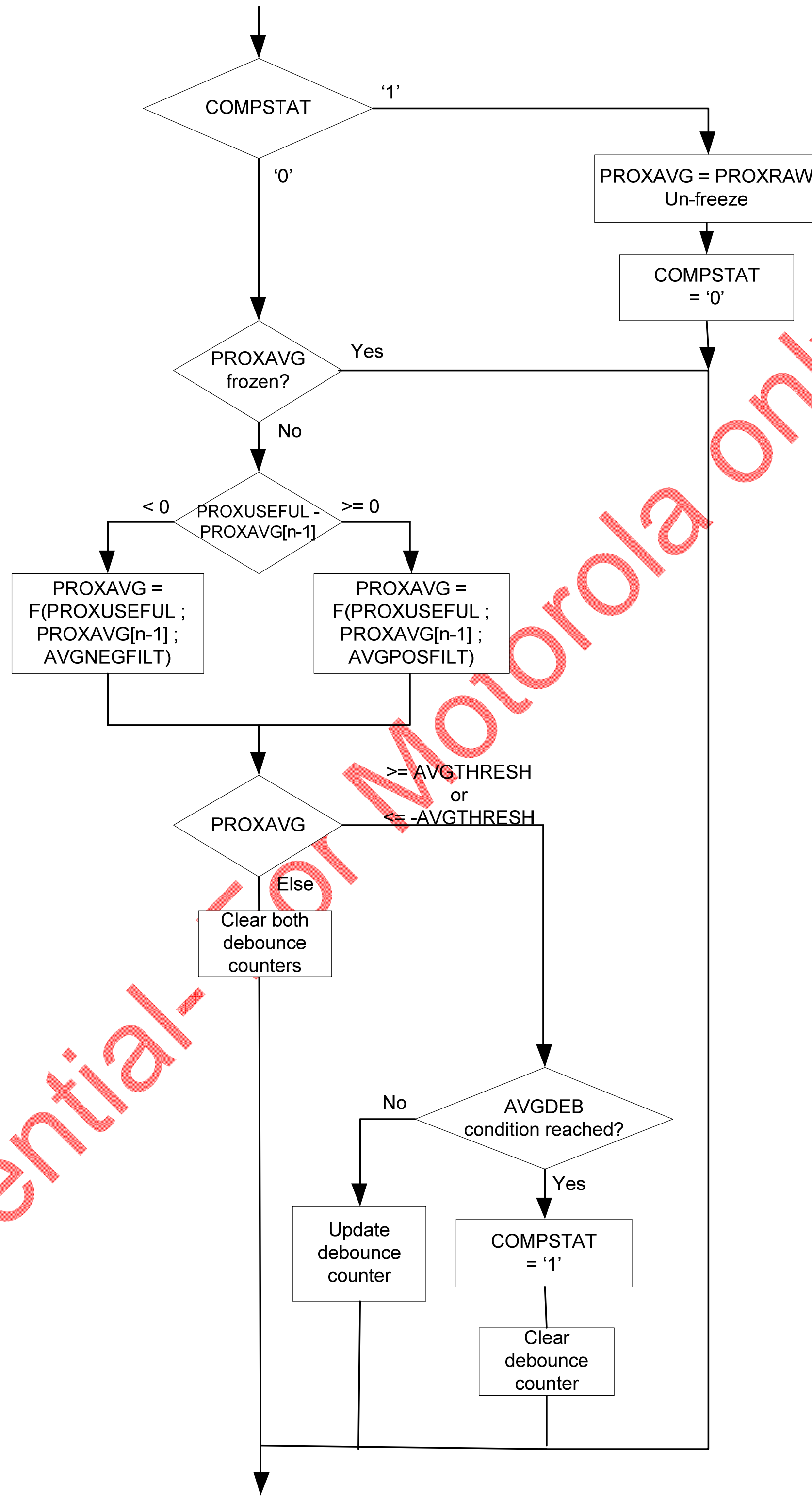


Figure 17: ProxAvg Update

F(PROXUSEFUL ; PROXAVG[n-1] ; AVGxxxFILT) = (1 - AVGxxxFILT).PROXUSEFUL + AVGxxxFILT.PROXAVG[n-1]

xxx = POS or NEG

3.4.5 PROXDIFF Update

PROXDIFF update consists of the complementary operation i.e. subtracting PROXAVG to PROXUSEFUL to ignore slow capacitances variations (C_{Env}) and extract only user related variations i.e. C_{User}.

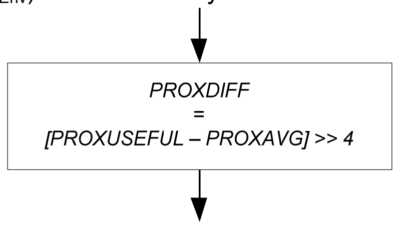


Figure 18: ProxDiff Update

Note that only the 12 upper bits of [PROXUSEFUL – PROXAVG] are kept for PROXDIFF.

3.4.6 PROXSTAT Update

PROXSTAT update consists of taking PROXDIFF information (C_{User}), comparing it with a user programmable threshold PROXTHRESH and finally updating PROXSTAT accordingly. When PROXSTAT=1, PROXAVG is typically frozen to prevent the user proximity signal from being absorbed into C_{Env}.

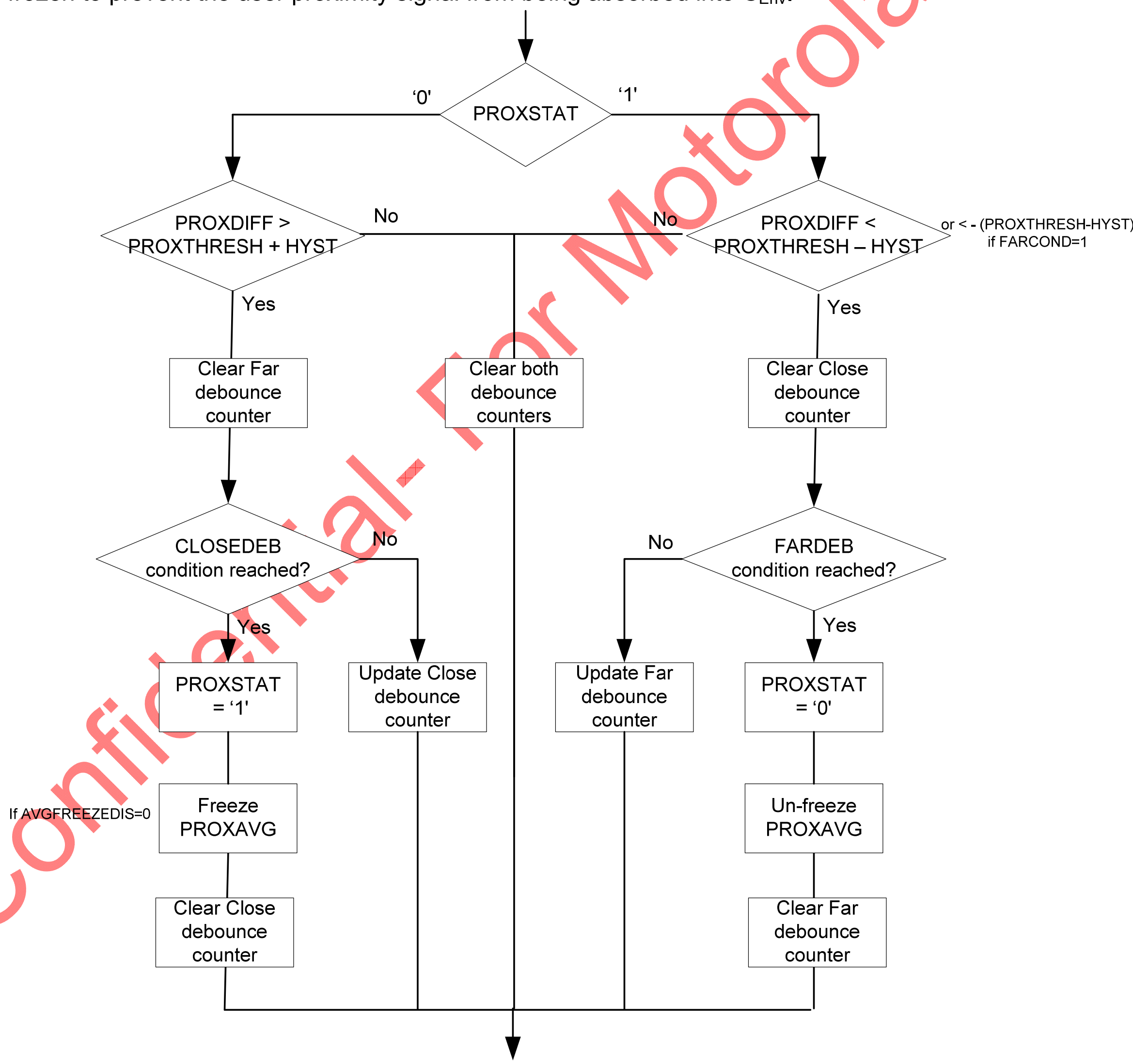


Figure 19: PROXSTAT Update

3.5 Host Operation

An interrupt can be triggered when the user is detected as "close" (in range), detected as "far" (out of range), or both (CLOSEIRQEN, FARIRQEN).

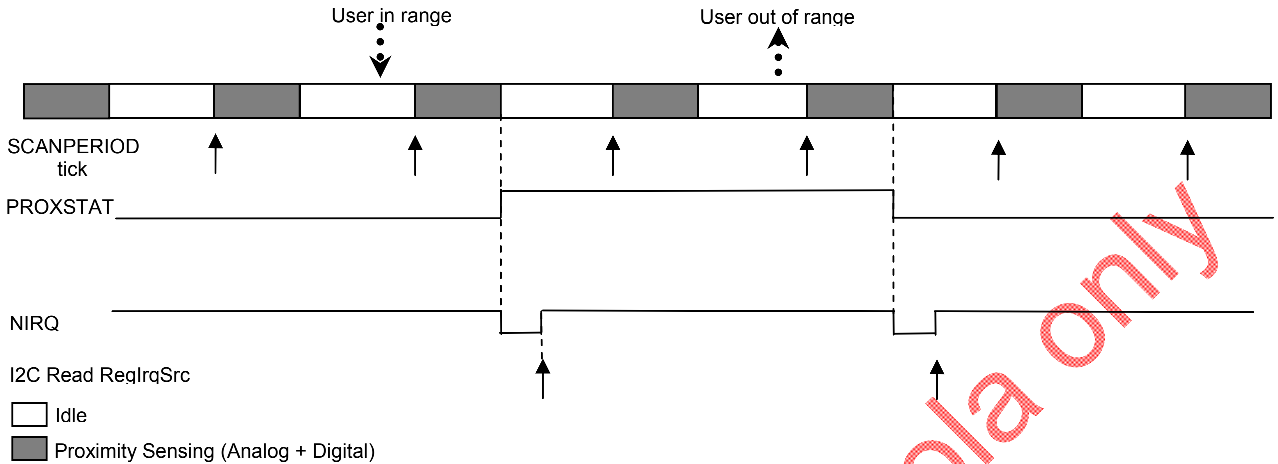


Figure 20: Proximity Sensing Host Operation (RegIrqMsk[6:3] = 1100)

An interrupt can also be triggered at the end of each proximity sensing operation, indicating to the host when the proximity sensing block is running (CONVDONEIRQEN). This may be used by the host to synchronize noisy system operations or to read sensor data (PROXUSEFUL, PROXAVG, PROXDIFF) synchronously for monitoring purposes.

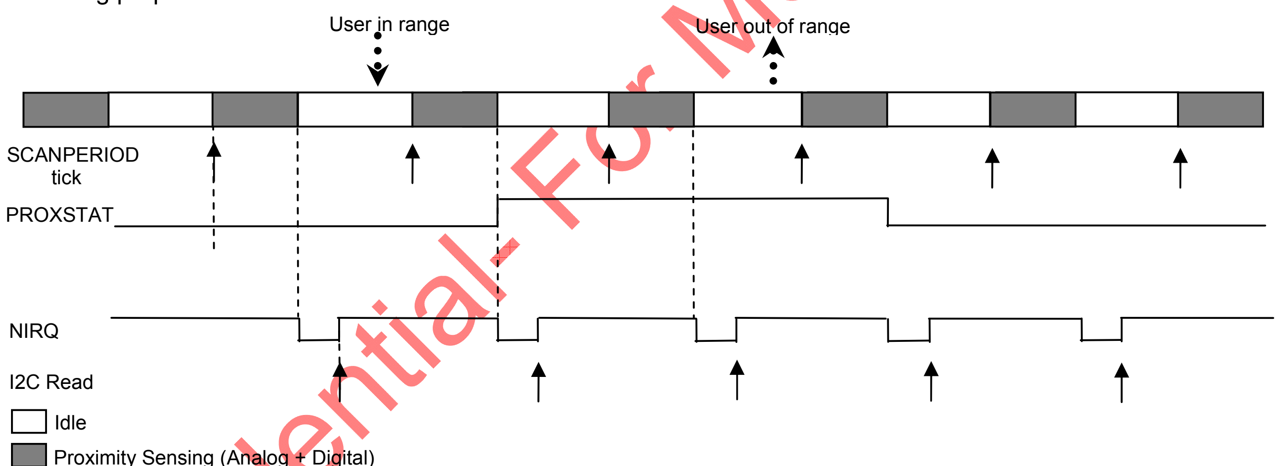


Figure 21: Proximity Sensing Host Operation (RegIrqMsk[6:3] = 0001)

In both cases above, an interrupt can also be triggered at the end of compensation (COMPDONEIRQEN).

3.6 Operational Modes

3.6.1 Active

Active mode has short scan periods, typically 30ms. In this mode, all enabled sensors are scanned and information data is processed within this interval. The Active scan period is user configurable (SCANPERIOD).

3.6.2 Doze

In some applications, the reaction/sensing time needs to be fast when the user is present (proximity detected), but can be slow when no detection has occurred for some time.

The Doze mode, when enabled (DOZEPERIOD), allows the chip to automatically switch between a fast scan period (SCANPERIOD) during proximity detection and a slow scan period (DOZEPERIOD) when no proximity is detected. This enables a lower average power consumption at the expense of longer reaction times.

As soon as proximity is detected on any sensor, the chip will automatically switch to Active mode. Conversely when it has not detected an object for DOZEPERIOD, it will automatically switch to Doze mode.

3.6.3 Sleep

Sleep mode can be entered by disabling all sensors (SENSOREN=0000). It places the chip in its lowest power mode, with sensor scanning completely disabled and idle period set to continuous. In this mode, only the I2C serial bus is active. Enabling any sensor will make the chip leave Sleep mode (for Doze if enabled, else Active mode).

4 SMART ENGINE FOR SAR

4.1 Introduction

In addition to the proximity sensing interface, the SX9310 also embeds the world's first smart engine for SAR which is able to discriminate **at a distance** between proximity generated by low permittivity (table) and high permittivity objects (body).

This is typically useful for Specific Absorption Rate (SAR) applications in portable devices (tablets, cellphones, etc) where international regulations (FCC, ETSI, etc) impose RF power reductions in the presence of human body for safety reasons.

Typical capacitive sensing solutions are not able to discriminate between proximity detection generated when a tablet (for example) is sitting on a table (no need to reduce RF power) versus when it is sitting on the user's lap (need to reduce RF power) resulting in RF power and hence user's experience reduced significantly even when it is not needed.

The SX9310's smart engine for SAR enables RF power reduction only in the presence of body (high permittivity material) and hence offering significantly better user experience while still conforming to safety regulations.

4.2 Sensor Design

In order to use the SX9310's smart engine for SAR, the sensors design must follow a few rules which are described in this section.

A smart SAR sensor is physically made of two sensors (outer and inner) connected respectively to pins CS1 and CS2. In the drawing below, the dark areas represent copper (conductor) and the light areas represents a non-conductor (spacing between the two copper areas).

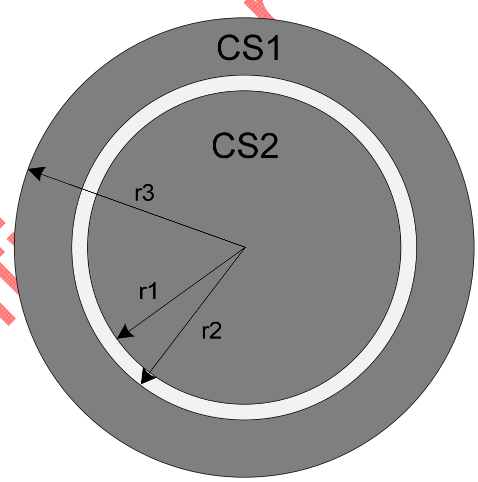


Figure 22: Typical Smart SAR Capacitive Sensor

IMPORTANT: The "CS1" and "CS2" sensors cannot be swapped. The outer copper area is always the "CS1" sensor, and the inner copper area is always the "CS2" sensor else the smart engine for SAR will not operate properly.

For best performance/robustness, the copper areas of CS1 and CS2 pads must be designed to be equal (as equal as the FPC/PCB technology tolerance allows).

The figure above illustrates an example of circular shape but smart SAR sensors can of course be designed in a variety of shapes (square, rectangular) depending on the physical/mechanical constraints of the system.

4.3 Processing

The smart engine for SAR is active when SAREN=1 and PROXSTAT12 is set (i.e. both CS1 and CS2 sensors have detected proximity).

When active, the smart engine for SAR computes a real time SAR threshold value a*CS2+b and updates BODYSTAT12 accordingly (set to 1 when CS1 > (SARSLOPE * CS2 + SAROFFSET) **OR** one of the two sensors is saturated i.e. > BODYTHRESH12).

Hysteresis and debounce mechanisms (SARHYST and SARDEB) can also be enabled on top of the threshold.

BODYSTAT12 (and TABLESTAT12, Cf. below) is **only** updated when average is frozen (i.e. AVGFREEZEDIS=0, or AVGFREEZEDIS=1 up to 4xAVGDEB).

TABLESTAT12 is built from BODYSTAT12 and PROXSTAT12 accordingly:

- When PROXSTAT12=0 => Set to 0

- Else, set to [NOT BODYSTAT12]

5 I2C INTERFACE

5.1 Introduction

The I2C implemented on the chip and used by the host to interact with it is compliant with:

- Standard (100kb/s) and fast mode (400kb/s)
- Slave mode
- 7-bit address (default is 0x28, can be modified by factory request)

The host can use the I2C to read and write data at any time, and these changes are effective immediately. Therefore the user may have to disable/enable sensors(s) or perform a compensation for the new settings to apply properly.

5.2 I2C Write

The format of the I2C write is given in the figure below. After the start condition [S], the slave address (SA) is sent, followed by an eighth bit ('0') indicating a Write. The chip then Acknowledges [A] that it is being addressed, and the master sends an 8-bit Data Byte consisting of Register Address (RA). The Slave Acknowledges [A] and the master sends the appropriate 8-bit Data Byte (WD0). Again the Slave Acknowledges [A]. In case the master needs to write more data, a succeeding 8-bit Data Byte will follow (WD1), acknowledged by the slave [A]. This sequence will be repeated until the master terminates the transfer with the Stop condition [P].

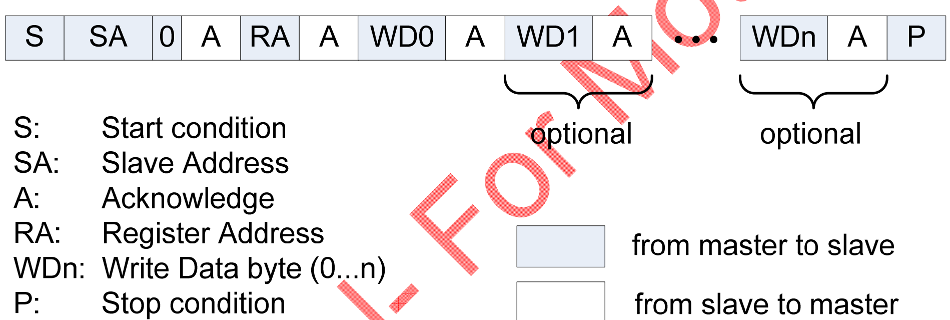


Figure 23: I2C Write

The register address is incremented automatically when successive register data (WD1...WDn) is supplied by the master.

5.3 I2C Read

The format of the main I2C read is given in the figure below. After the start condition [S], the slave address (SA) is sent, followed by an eighth bit ('0') indicating a Write. The SX9310 then Acknowledges [A] that it is being addressed, and the Master responds with an 8-bit Data consisting of the Register Address (RA). The Slave Acknowledges [A] and the master sends the Repeated Start Condition [Sr]. Once again, the slave address (SA) is sent, followed by an eighth bit ('1') indicating a Read. The SX9310 responds with an Acknowledge [A] and the read Data byte (RD0). If the master needs to read more data it will acknowledge [A] and the chip will send the next read byte (RD1). This sequence can be repeated until the master terminates with a NACK [N] followed by a stop [P].

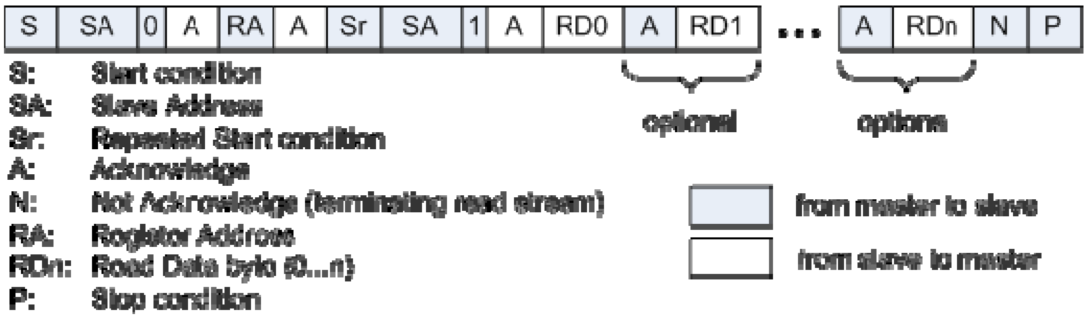


Figure 24: I2C Read

The register address is incremented automatically when successive register data (RD1...RDn) is retrieved by the master.

An “immediate” read can also be performed by the master. In this procedure data is transmitted from the slave to the master from the register address currently pointed to (last accessed from previous read or write). The slave address is sent followed by an eighth bit (‘1’) indicating a Read. The SX9310 responds with an Acknowledge [A] and the read Data byte (RD0). If the master needs to read more data it will acknowledge [A] and the chip will send the next read byte (RD1). This sequence can be repeated until the master terminates with a NACK [N] followed by a stop [P].

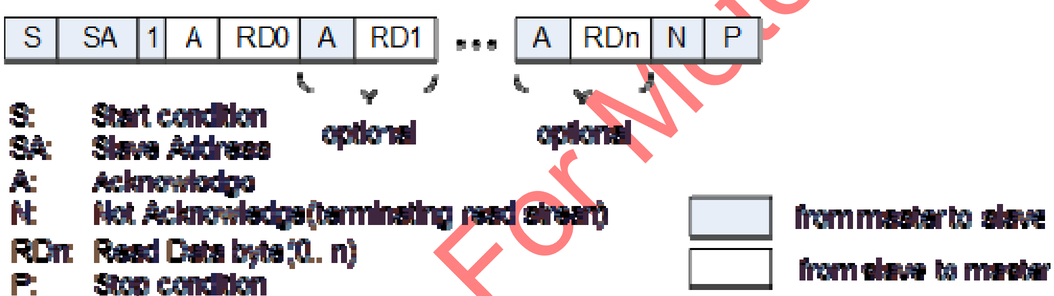


Figure 25: I2C Immediate Read

The register address is incremented automatically when successive register data (RD1...RDn) is retrieved by the master.

6 RESET

6.1 Power-up

During a power-up condition, and if IRQFUNCTION=0000, the NIRQ output is HIGH until **both** V_{DD} and SV_{DD} have met their minimum input voltage requirements and a T_{POR} time has expired upon which, NIRQ asserts to a LOW condition indicating that the chip is initialized. The host must perform an I2C read of RegIrqSrc to clear this NIRQ status. The chip is then ready for normal I2C communication and is operational.

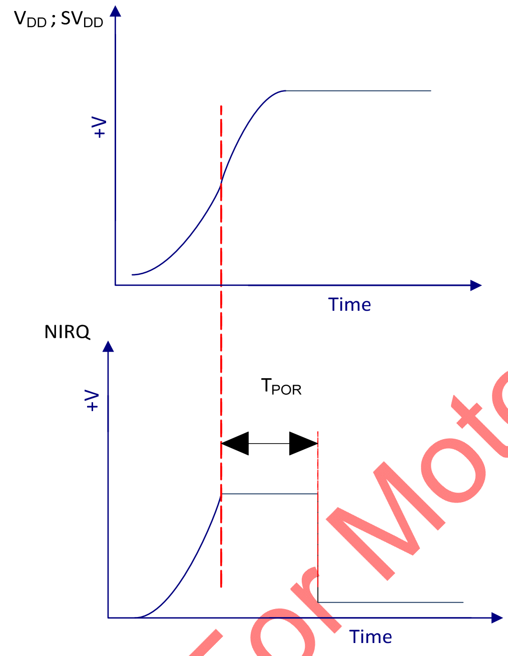


Figure 26: Power-up vs. NIRQ

6.2 Software Reset

The host can also perform a reset anytime by writing 0xDE into RegReset. The NIRQ output will be asserted LOW and the Host is required to perform an I2C read to clear this NIRQ status.

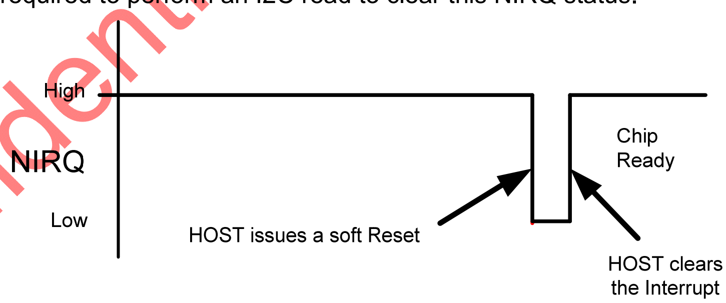


Figure 27: Software Reset

7 INTERRUPT

7.1 Power-up

During initial power-up, the NIRQ output is HIGH. Once the chip's internal power-up sequence has completed, NIRQ is asserted LOW, signaling that the chip is ready. The host must perform a read to RegIrqSrc to acknowledge and the chip will clear the interrupt and release the NIRQ line.

7.2 Assertion and Clearing

Except for Reset, the NIRQ pin can be asserted once per scan period in the processing phase. It will be automatically cleared after the host performs a read of RegIrqSrc (which content will be cleared as well).

8 REGISTERS

8.1 Overview

The registers below allow the user to do full parameter customization.

Address	Name	Description
0x00	RegIrqSrc	Interrupt & Status
0x01	RegStat0	
0x02	RegStat1	
0x03	RegIrqMsk	
0x04	RegIrqFunc	
0x10	RegProxCtrl0	Proximity Sensing Control
0x11	RegProxCtrl1	
0x12	RegProxCtrl2	
0x13	RegProxCtrl3	
0x14	RegProxCtrl4	
0x15	RegProxCtrl5	
0x16	RegProxCtrl6	
0x17	RegProxCtrl7	
0x18	RegProxCtrl8	
0x19	RegProxCtrl9	
0x1A	RegProxCtrl10	
0x1B	RegProxCtrl11	
0x1C	RegProxCtrl12	
0x1D	RegProxCtrl13	
0x1E	RegProxCtrl14	
0x1F	RegProxCtrl15	
0x20	RegProxCtrl16	
0x21	RegProxCtrl17	
0x22	RegProxCtrl18	
0x23	RegProxCtrl19	
0x2A	RegSarCtrl0	Smart Engine for SAR Control
0x2B	RegSarCtrl1	
0x2C	RegSarCtrl2	
0x30	RegSensorSel	Sensor Data Readback
0x31	RegUseMsb	
0x32	RegUseLsb	
0x33	RegAvgMsb	
0x34	RegAvgLsb	
0x35	RegDiffMsb	
0x36	RegDiffLsb	
0x37	RegOffsetMsb	
0x38	RegOffsetLsb	
0x39	RegSarMsb	
0x3A	RegSarLsb	
0x40	RegI2cAddr	Miscellaneous
0x41	RegPause	
0x42	RegWhoAmI	
0x7F	RegReset	

Table 8: Register Overview

NOTES:
1) Addresses not listed above are reserved and should not be written.
2) Reserved bits should be left to their default value unless otherwise specified.

8.2 Detailed Description

Variables marked with a * have part or all of their bits (in **red bold**) default values burnable in NVM (please contact your Semtech representative for more information).

Addr.	Name	R/W	Bits	Variable	Default	Function
				Interrupt & Status		
0x00	RegIrqSrc	R	7	RESETIRQ	1	Reset interrupt source status. (i.e. reset occurred)
			6	CLOSEANYIRQ	0	Close interrupt source status. (i.e. any rising edge Cf. ANYIRQCONFIG)
			5	FARANYIRQ	0	Far interrupt source status. (i.e. any falling edge Cf. ANYIRQCONFIG)
		RW	4	COMPDONEIRQ	0	Compensation interrupt source status. (i.e. any COMPSTAT bit's falling edge) When set to 1, triggers compensation for **all** sensors independently from their PROXSTAT value.
		R	3	CONVDONEIRQ	0	Conversion interrupt source status. (i.e. CONVSTAT falling edge)
			2	CLOSEALLIRQ	0	ALL Close interrupt source status. (i.e. PROXSTATALL rising edge)
			1	FARALLIRQ	0	ALL Far interrupt source status. (i.e. PROXSTATALL falling edge)
			0	SMARTSARIRQ	0	Smart SAR interrupt source status (i.e. SMARTSARSTAT rising or falling edge)
0x01	RegStat0	R	7	TABLESTAT12	0	If SAREN=1, when PROXSTAT12=1, indicates if the object currently detected by CS1/CS2 pair is recognized as a table. (i.e. = NOT BODYSTAT12; SARHYST and SARDEB apply) When PROXSTAT12=0, set to 0. If SAREN=0, when PROXSTAT2=1, indicates if the object currently detected by CS2 is recognized as a human body. (i.e. sensor exceeds BODYTHRESH12; HYST and CLOSE/FARDEB apply) When PROXSTAT2=0, set to 0.
			6	BODYSTAT12	0	If SAREN=1, when PROXSTAT12=1, indicates if the object currently detected by CS1/CS2 pair is recognized as a human body (set as defined by SAREN **or** if one of the sensors exceeds BODYTHRESH12) When PROXSTAT12=0, set to 0. If SAREN=0, when PROXSTAT1=1, indicates if the object currently detected by CS1 is recognized as a human body. (i.e. sensor exceeds BODYTHRESH12; HYST and CLOSE/FARDEB apply) When PROXSTAT1=0, set to 0.
			5	SMARTSARSTAT	0	If SAREN=1, Smart SAR flag as defined in SARSTATCONFIG. If SAREN=0, when PROXSTATCOMB=1, indicates if the object currently detected by COMB is recognized as a human body. (i.e. sensor exceeds BODYTHRESH0; HYST and CLOSE/FARDEB apply) When PROXSTATCOMB=0, set to 0.
			4	BODYSTAT0	0	When PROXSTAT0=1, indicates if the object currently detected by CS0 is recognized as a human body. (i.e. sensor exceeds BODYTHRESH0; HYST and CLOSE/FARDEB apply) When PROXSTAT0=0, set to 0.
			3	PROXSTATCOMB	0	Indicates if proximity is currently being

						detected for combined sensor. (i.e. set when sensor's PROXDIFF value is above detection threshold, Cf. FARCOND for clearing condition)
			2	PROXSTAT2	0	Indicates if proximity is currently being detected for CS2. (i.e. set when sensor's PROXDIFF value is above detection threshold, Cf. FARCOND for clearing condition)
			1	PROXSTAT1	0	Indicates if proximity is currently being detected for CS1 (i.e. set when sensor's PROXDIFF value is above detection threshold, Cf. FARCOND for clearing condition)
			0	PROXSTAT0	0	Indicates if proximity is currently being detected for CS0 (i.e. set when sensor's PROXDIFF value is above detection threshold, Cf. FARCOND for clearing condition)
0x02	RegStat1	R	7	PROXSTAT12	0	Indicates if proximity is being detected for the pair CS1/CS2 (i.e. set when both PROXSTAT1&2 are set)
			6	PROXSTATANY	0	Indicates if proximity is currently being detected by ANY (i.e. at least one) of the enabled sensors; Cf. ANYIRQCONFIG.
			5	PROXSTATALL	0	Indicates if proximity is currently being detected by ALL of the **enabled** sensors (0/1/2/COMB)
			4	CONVSTAT	0	Indicates that a new set of sensor data is currently being measured.
			3:0	COMPSTAT	0000	Indicates which sensor(s) has compensation pending/running. [3:0] = [COMB, CS2, CS1, CS0]
0x03	RegIrqMsk	RW	7	ANYIRQCONFIG	0	Defines which RegStat0 bits are considered for the CLOSEANY and FARANY interrupts. 0: RegStat0 [3:0] 1: RegStat0 [7:0] When ANYIRQCONFIG=1 and SAREN=0; RegStat0[5]/[6]/[7] will only trigger an interrupt if SENSOREN[1]/[2]/[3] are set/enabled respectively. When ANYIRQCONFIG=1 and SAREN=1; RegStat0[7] will only trigger an interrupt if SENSOREN[3] is set/enabled.
			6	CLOSEANYIRQEN	1	Enables the close interrupt (Any).
			5	FARANYIRQEN	1	Enables the far interrupt (Any).
			4	COMPDONEIRQEN	0	Enables the compensation interrupt.
			3	CONVDONEIRQEN	0	Enables the conversion interrupt.
			2	CLOSEALLIRQEN	0	Enables the ALL close interrupt.
			1	FARALLIRQEN	0	Enables the ALL far interrupt.
			0	SMARTSARIRQEN	0	Enables the Smart SAR interrupt
0x04	RegIrqFunc	R	7:6	Reserved	00	
		RW	5	IRQPOLARITY	**0**	Defines the NIRQ pin polarity: 0: Normal (Typ.) 1: Inverted Normal polarity is "Active Low" when IRQFUNCTION=0000, else "Active High".
		RW	4:1	IRQFUNCTION*	00**0**0	Defines NIRQ pin function: 0000: Interrupt (Typ.)

						0001: PROXSTATANY 0010: PROXSTAT0 0011: PROXSTAT1 0100: PROXSTAT2 0101: PROXSTATCOMB 0110: PROXSTAT12 0111: PROXSTATALL 1000: BODYSTAT0 1001: BODYSTAT12 1010: TABLESTAT12 1011: SMARTSARSTAT 1100: CONVSTAT 1101: COMPSTAT (Any) 1110: High (not impacted by IRQPOLARITY) 1111: Low (not impacted by IRQPOLARITY)
		RW	0	IRQMODE*	0	Defines the NIRQ pin mode: 0: Open-Drain (Typ.) 1: Push-Pull
Proximity Sensing Control						
0x10	RegProxCtrl0	RW	7:4	SCANPERIOD*	0010	Defines the Active scan period : 0000: Min (no idle time) 0001: 15 ms 0010: 30 ms (Typ.) 0011: 45 ms 0100: 60 ms 0101: 90 ms 0110: 120 ms 0111: 200 ms 1000: 400 ms 1001: 600 ms 1010: 800 ms 1011: 1 s 1100: 2 s 1101: 3 s 1110: 4 s 1111: 5 s Low values will allow fast reaction time while high values will provide low power consumption.
			3:0	SENSOREN*	0000	Enables sensor pins/measurements. [3:0] = [COMB, CS2, CS1, CS0] When any SENSOREN bit is set a compensation (and start-up detection if enabled) is automatically performed for that channel. When SAREN =1, both CS1 and CS2 must be enabled.
0x11	RegProxCtrl1	R	7:2	Reserved	000000	
		RW	1:0	CSIDLESLEEP	00	Defines/Controls the status of the CSx pins during sleep mode and idle time. 0x: HZ (default) 10: GND 11: VDD
0x12	RegProxCtrl2	RW	7:6	COMBMODE	00	Defines which sensors are used for the COMB measurement: 00: CS3 (Internal) 01: CS0+CS1 10: CS1+CS2 11: CS0+CS1+CS2+CS3
		RW	5:4	Reserved	00	
		RW	3:2	SHIELDEN	01	Defines the behavior of the CS0 pin when

						others are being measured: 00: As defined by CSOFF. 01: Dynamic shield (typ.) 10: Ground 11: Reserved
		RW	1:0	CSOFF*	00	Defines the behavior of the CS1/2/3 pins when others are being measured: 0x: As defined by SHIELDEN; except if SHIELDEN=00 or CS0 is being measured (High Impedance). 10: High Impedance 11: Ground
0x13	RegProxCtrl3	RW	7:4	Reserved	0000	
			3:2	GAIN0*	00	Defines the digital factor for CS0 and COMB (and CS2 if CS2CONFIG=1): 00: Off (x1) 01: x2 10: x4 11: x8 This is a pure digital gain (value shift) applied at the ADC output.
			1:0	GAIN12	00	Defines the digital gain for CS1 and CS2 (if CS2CONFIG=0): 00: Off (x1) 01: x2 10: x4 11: x8 This is a pure digital gain (value shift) applied at the ADC output.
0x14	RegProxCtrl4	RW	7:3	FREQ*	00001	Defines the sampling frequency: 00000: 250 kHz 00001: 166.7 kHz (Typ.) 00010: 125 kHz 00011: 100 kHz 00100: 83 kHz 00101: 71.4 kHz 00110: 62.5 kHz 00111: 55.6 kHz 01000: 50 kHz 01001: 45.5 kHz 01010: 41.7 kHz 01011: 38.5 kHz 01100: 35.7 kHz 01101: 33.3 kHz 01110: 31.3 kHz 01111: 29.4 kHz 10000: 27.8 kHz 10001: 26.3 kHz 10010: 25 kHz 10011: 23.8 kHz 10100: 22.7 kHz 10101: 21.7 kHz 10110: 20.8 kHz 10111: 20 kHz 11000: 19.2 kHz 11001: 18.5 kHz 11010: 17.9 kHz 11011: 17.2 kHz 11100: 16.7 kHz 11101: 16.1 kHz 11110: 15.6 kHz 11111: 15.1 kHz

			2:0	RESOLUTION*	101	Defines the capacitance measurement resolution/precision: 000: Coarsest 001: Very Coarse 010: Coarse 011: Medium Coarse 100: Medium 101: Fine (Typ.) 110: Very Fine 111: Finest
0x15	RegProxCtrl5	RW	7:6	RANGE*	11	Defines the typical full scale input capacitance range: 00: Large (+/-7.5pF) 01: Medium (+/-3.75pF) 10: Medium Small (+/-3.0pF) 11: Small (+/-2.5pF) This parameter can be seen as an analog gain (small range = high gain) Full scale values assume no digital gain.
			5:4	DOZEPERIOD	00	Enables Doze mode and defines its scan period: 00: OFF 01: 4x SCANPERIOD 10: 8x SCANPERIOD 11: 16x SCANPERIOD When SCANPERIOD=0000, 30ms is used to calculate DOZEPERIOD.
			3:2	STARTUPSENS	00	Defines which sensor is used for start-up proximity detection: 00: CS0 01: CS1 10: CS2 11: COMB
			1:0	RAWFILT*	01	Defines PROXRAW filter strength : 00: 0 (Off) 01: 1-1/2 (Typ.) 10: 1-1/4 11: 1-1/8
0x16	RegProxCtrl6	RW	7	AVGTHRESHINIT	0	Defines the initial value used to calculate average thresholds: 0: 0 1: ~Average value after last compensation
			6	AVGCOMPMETHOD	0	Defines the average compensation method: 0: Individual. Each sensor triggers only its own compensation 1: Common. Any sensor triggers compensation of all channels.
			5:0	AVGTHRESH*	100000	Defines the average thresholds which will trigger compensation: 0000000: OFF, no automatic comp. Else: Thresholds = AVGTHRESHINIT +/- 512 x AVGTHRESH Typically set between +/-16384 and +/-24576 (i.e. ½ to ¾ of the system dynamic range). When AVGTHRESHINIT=0, should not be set below 010000 (except to turn it OFF). When AVGTHRESHINIT=1, should not be set above 110000 (except to turn it OFF).

						Sensors are compensated individually or altogether depending on COMPMETHOD.
0x17	RegProxCtrl7	RW	7:6	AVGDEB	01	Defines the average debouncer applied to AVGTHRESH: 00: Off 01: 2 samples 10: 4 samples 11: 8 samples
			5:3	AVGNEGFILT	001	Defines the average negative filter strength: 000: 0 (Off) 001: 1-1/2 (Typ.) 010: 1-1/4 011: 1-1/8 100: 1-1/16 101: 1-1/32 110: 1-1/64 111: 1 (Infinite)
			2:0	AVGPOSFILT*	100	Defines the average positive filter strength: 000: 0 (Off) 001: 1-1/16 010: 1-1/64 011: 1-1/128 100: 1-1/256 (Typ.) 101: 1-1/512 110: 1-1/1024 111: 1 (Infinite)
0x18	RegProxCtrl8	RW	7:4	PROXTHRESH0*	00100	Defines the proximity detection threshold for CS0 and COMB (and CS2 if CS2CONFIG=1): 00000: 2 00001: 4 00010: 6 00011: 8 00100: 12 00101: 16 00110: 20 00111: 24 01000: 28 01001: 32 01010: 40 01011: 48 01100: 56 01101: 64 01110: 72 01111: 80 10000: 88 10001: 96 10010: 112 10011: 128 10100: 144 10101: 160 10110: 192 10111: 224 11000: 256 11001: 320 11010: 384 11011: 512 11100: 640 11101: 768 11110: 1024 11111: 1536
			3:0	BODYTHRESH0	110	Defines the body detection threshold for CS0 and COMB (and CS2 if CS2CONFIG=1): 000: OFF 001: PROXDIFF > 300

						010: PROXDIFF > 600 011: PROXDIFF > 900 100: PROXDIFF > 1200 101: PROXDIFF > 1500 110: PROXDIFF > 1800 111: PROXUSEFUL > 30000
0x19	RegProxCtrl9	RW	7:3	PROXTHRESH12	00100	Defines the proximity detection threshold for CS1 and CS2 (if CS2CONFIG=0). 00000: 2 00001: 4 00010: 6 00011: 8 00100: 12 00101: 16 00110: 20 00111: 24 01000: 28 01001: 32 01010: 40 01011: 48 01100: 56 01101: 64 01110: 72 01111: 80 10000: 88 10001: 96 10010: 112 10011: 128 10100: 144 10101: 160 10110: 192 10111: 224 11000: 256 11001: 320 11010: 384 11011: 512 11100: 640 11101: 768 11110: 1024 11111: 1536
			2:0	BODYTHRESH12	111	Defines the body detection/saturation threshold for CS1 and CS2 (if CS2CONFIG=0). 000: OFF 001: PROXDIFF > 300 010: PROXDIFF > 600 011: PROXDIFF > 900 100: PROXDIFF > 1200 101: PROXDIFF > 1500 110: PROXDIFF > 1800 111: PROXUSEFUL > 30000
0x1A	RegProxCtrl10	RW	7	AVGFREEZEDIS	0	Disables Average freezing during prox. 0: As soon as prox is detected, average is frozen until prox is released. (Typ.) 1: As soon as prox is detected, average is frozen for max 4xAVGDEB samples and then unfrozen (even if prox is not released). When SAREN=1, BODYSTAT12 and TABLESTAT12 are **only** updated when average is frozen (i.e. AVGFREEZEDIS=0, or AVGFREEZEDIS=1 until 4xAVGDEB) AVGFREEZEDIS=1 is typically used when

						FARCOND=1.
			6	FARCOND	0	Defines the far/release/non-prox condition: 0: PROXDIFF < (THRESH-HYST) (Typ.) 1: PROXDIFF < - (THRESH-HYST) FARCOND=1 is typically used when AVGFREEZEDIS=1.
			5:4	HYST*	00	Defines the proximity detection hysteresis applied to PROX/BODYTHRESH: 00: None 01: +/- 6% (Thresh>>4) 10: +/- 12% (Thresh>>3) 11: +/- 25% (Thresh>>2)
			3:2	CLOSEDEB	00	Defines the Close debouncer applied to PROX/BODYTHRESH: 00: Off 01: 2 samples 10: 4 samples 11: 8 samples
			1:0	FARDEB	00	Defines the Far debouncer applied to PROX/BODYTHRESH: 00: Off 01: 2 samples 10: 4 samples 11: 8 samples
0x1B	RegProxCtrl11	RW	7	STARTUPFREQ*	0	Defines when the “start-up” detection is performed: 0: Only after SENSOREN compensation 1: After each compensation
			6	STARTUPMETH*	0	Defines the start-up detection method: 0: After the compensation is performed, PROXOFFSET (and PROXUSEFUL) of sensor defined in STARTUPSENS, is compared with OFFSETTHRESH (and USEFULTHRESH). If [PROXOFFSET > OFFSETTHRESH] OR ([PROXOFFSET = OFFSETTHRESH] AND [PROXUSEFUL > USEFULTHRESH]) => Set PROXSTAT to 1 **and set it back to 0 only when [PROXOFFSET < OFFSETTHRESH]** OR **([PROXOFFSET = OFFSETTHRESH] AND [PROXUSEFUL < USEFULTHRESH])** Then start normal processing. Else => Set PROXSTAT to 0 and start normal processing. 1: After the compensation is performed, PROXOFFSET of sensor defined in STARTUPSENS is temporarily forced to OFFSETTHRESH and PROXUSEFUL compared to USEFULTHRESH (PROXAVG frozen) If[PROXUSEFUL > USEFULTHRESH] => Set PROXSTAT to 1, **and set it back to 0 only when [PROXUSEFUL < USEFULTHRESH], then** restore original PROXOFFSET result (from last compensation) and start normal processing.

						Else => Set PROXSTAT to 0, restore original PROXOFFSET and start normal processing. **Important:** PROXUSEFUL values used for start-up detection (and everything else) are the ones AFTER the reference sensor correction (if enabled) has been applied.
			5:0	OFFSETTHRESH*	**000000**	Enables start-up proximity detection and defines offset threshold. 0x0000: Off, no start-up detection performed Else: Start-up detection offset threshold.
0x1C	RegProxCtrl12	RW	7:0		**0x00**	
0x1D	RegProxCtrl13	RW	7:0	USEFULTHRESH*	**0x00**	Defines useful threshold of start-up proximity detection. Signed, 2's complement format.
0x1E	RegProxCtrl14	RW	7:0		0x00	
0x1F	RegProxCtrl15	RW	7:0	REFCAL	0x00	Defines the reference sensor calibration value. Signed, 2's complement format.
0x20	RegProxCtrl16	RW	7:0		0x00	
0x21	RegProxCtrl17	RW	7:5	Reserved	000	
			4	REFEN	0	Enables reference sensor correction: 0: Off, all sensors work normally 1: On, the sensor defined by REFSENSOR is used to correct the other sensors measurements as defined by REFMETHOD.
			3	REFMETHOD	0	Defines how the correction is applied: 0: Useful, all the time. Useful(n) = Useful(n) **-** REFCOEF* [RefUseful(n) – RefUseful0C] RefUseful0C corresponds to the value right after last compensation; except if PROXOFFSET=OFFSETTHRESH, then REFCAL is used instead for that (those) specific sensor(s) correction. Note that when REFMETHOD=0, the exact coefficient applied depends on RAWFILT. 1: Average, only when it is “frozen”. Average(n) = Average0F **+** REFCOEF* [RefUseful(n) – RefUseful0F] Average0F and RefUseful0F correspond to the values right after Average has been Frozen (i.e. right after prox detection)
			2:1	REFSENSOR	10	Defines which sensor is used for reference: 00: CS0 01: CS1 10: CS2 11: COMB
			0	Reserved	0	
0x22	RegProxCtrl18	RW	7:0	REFCOEF0	0x00	Defines the reference coefficient for CS0 and COMB (and CS2 if CS2CONFIG=1): Coded on 8 bits as **XXX.YYYYY**. 0x00: 0 (Off, no correction applied) 0x01: 0.03125 … 0x20: 1 … 0xFF: 7.96875
0x23	RegProxCtrl19	RW	7:0	REFCOEF12	0x00	Defines the reference coefficient for CS1 and CS2 (if CS2CONFIG=0). Coded on 8 bits as **XXX.YYYYY**.

						0x00: 0 (Off, no correction applied) 0x01: 0.03125 … 0x20: 1 … 0xFF: 7.96875.
Smart Engine for SAR Control						
0x2A	RegSarCtrl0	RW	7	SAREN	0	Enables smart engine for SAR: 0: Off, CS1 and CS2 are used as independent sensors 1: On, CS1 and CS2 are used as a smart SAR sensor. Cf. §4.
			6:5	SARDEB	00	Defines the body reporting debouncer applied to SAR threshold: 00: Off 01: 2 samples 10: 4 samples 11: 8 samples
			4:3	SARHYST	00	Defines the body detection hysteresis applied to SAR threshold: 00: None 01: 4 10: 8 11: 16
			2:1	SARSTATCONFIG	00	Defines when SMARTSARSTAT flag is high: 00: (PROXSTAT12=0 & PROXSTATANY=1) OR (PROXSTAT12=1 & BODYSTAT12=1) 01: (PROXSTAT12=0 & PROXSTATCOMB=1 OR (PROXSTAT12=1 & BODYSTAT12=1) 10: (PROXSTAT12=0 & PROXSTAT1=1) OR (PROXSTAT12=1 & BODYSTAT12=1) 11: (PROXSTAT12=1 & BODYSTAT12=1)
			0	CS2CONFIG	0	Defines which GAIN, PROXTHRESH, BODYTHRESH and REFCOEF settings apply to CS2: 0: GAIN12, PROXTHRESH12, BODYTHRESH12, REFCOEF12 (i.e. same as CS1) 1: GAIN0, PROXTHRESH0, BODYTHRESH0 REFCOEF0 (i.e. same as CS0)
0x2B	RegSarCtrl1	RW	7:0	SARSLOPE	0x80	Defines the slope of SAR threshold. Coded on 8 bits as **X.YYYYYYY.** 0x00: 0 0x01: 0.0078125 0x02: 0.015625 … 0x80: 1 … 0xFF: 1.9921875
0x2C	RegSarCtrl2	RW	7:0	SAROFFSET	0x0C	Defines the offset of SAR threshold. 0x00: 0 0x01: 1 … 0xFF: 255
Sensor Data Readback						
0x30	RegSensorSel	R	7:2	Reserved	000000	
		RW	1:0	SENSORSEL	00	Defines which sensor's data will be available in registers RegUseMsb to RegOffsetLsb (addr. 0x31 to 0x38): 00: CS0 01: CS1 10: CS2 11: COMB
0x31	RegUseMsb	R	7:0	PROXUSEFUL	0x00	Useful current value.

0x32	RegUseLsb	R	7:0		0x00	Signed, 2's complement format.
0x33	RegAvgMsb	R	7:0	PROXAVG	0x00	Average current value.
0x34	RegAvgLsb	R	7:0		0x00	Signed, 2's complement format.
0x35	RegDiffMsb	R	7:0	PROXDIFF	0x00	Diff current value.
0x36	RegDiffLsb	R	7:0		0x00	Signed, 2's complement format.
0x37	RegOffsetMsb	RW	7:0	PROXOFFSET	0x00	Compensation offset current value.
0x38	RegOffsetLsb	RW	7:0		0x00	Unsigned. If MSB is forced it must be followed by an LSB write for the change to be effective. LSB alone can be forced if needed. (MSB is then unchanged)
0x39	RegSarMsb	R	7:0	SARTHRESHMSB	0x00	Current MSB of SAR Threshold = (SARSLOPE * CS2 + SAROFFSET). Signed, 2's complement format.
0x3A	RegSarLsb	R	7:0	SARTHRESHLSB	0x00	Current LSB of SAR Threshold = (SARSLOPE * CS2 + SAROFFSET). Signed, 2's complement format.
Miscellaneous						
0x40	RegI2cAddr	R	7	Reserved	0	
		R	6:0	I2CADDRESS*	0101000	Defines the I2C Address.
0x41	RegPause	R	7:1	Reserved	0000000	
		RW	0	PAUSECTRL	1	1->0: Completes current measurements if needed and then goes to Sleep mode. 0->1: Resumes measurements normally at every scan period. This bit is only effective when IRQMODE=0.
0x42	RegWhoAmI	R	7:0	WHOAMI	0x01	Chip Identification Number.
0x7F	RegReset	W	7:0	SOFTRESET	0x00	Writing 0xDE resets the chip.

Table 9: Registers Detailed Description

9 APPLICATION INFORMATION

9.1 Typical Application Circuit

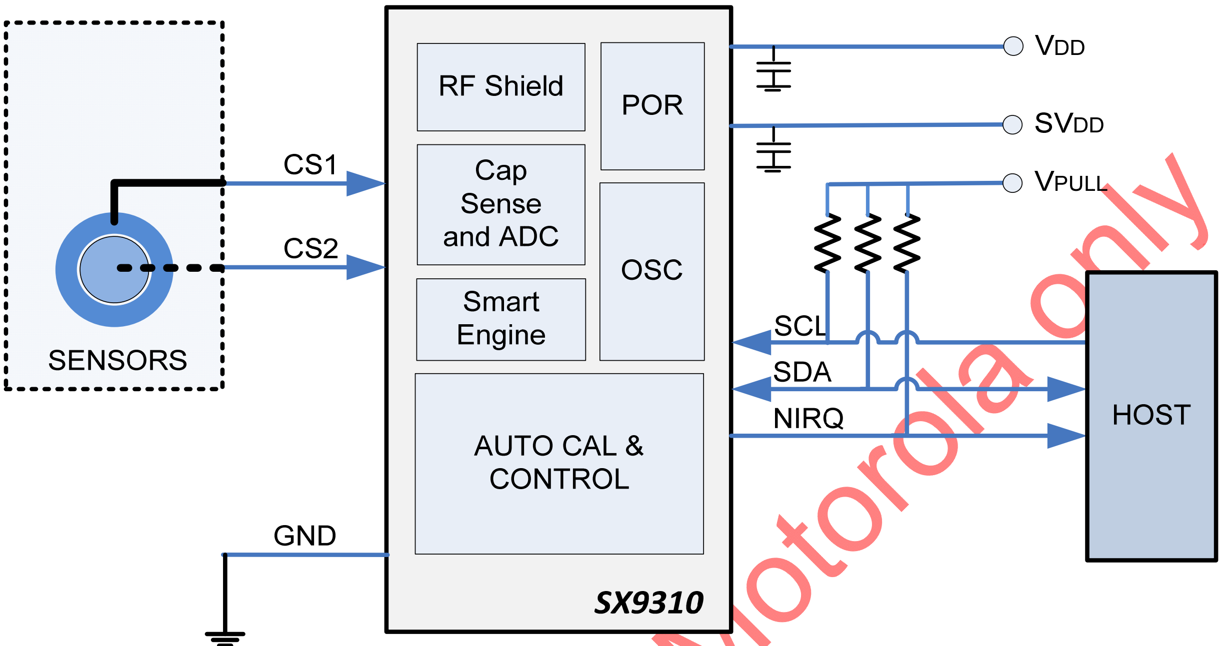


Figure 28: Typical Application Circuit

9.2 External Components Recommended Values

Symbol	Description	Note	Min	Typ.	Max	Unit
CVDD	Core supply decoupling capacitor		-	100	-	nF
CSVDD	Host interface supply decoupling capacitor		-	100	-	nF
RPULL	Host interface pull-ups		-	2.2	-	kΩ

Table 10: External Components Recommended Values

10 PACKAGING INFORMATION

10.1 Outline Drawing

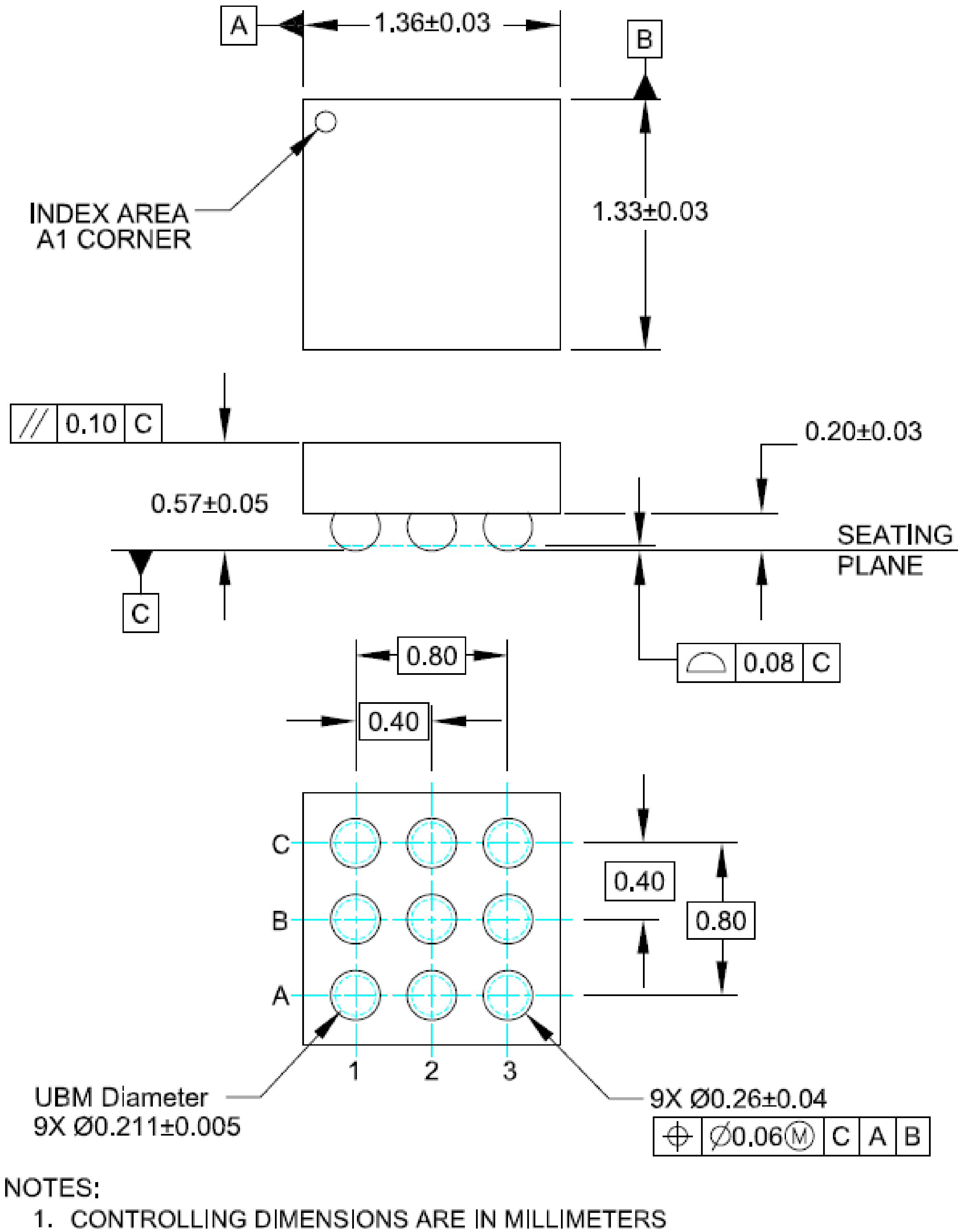
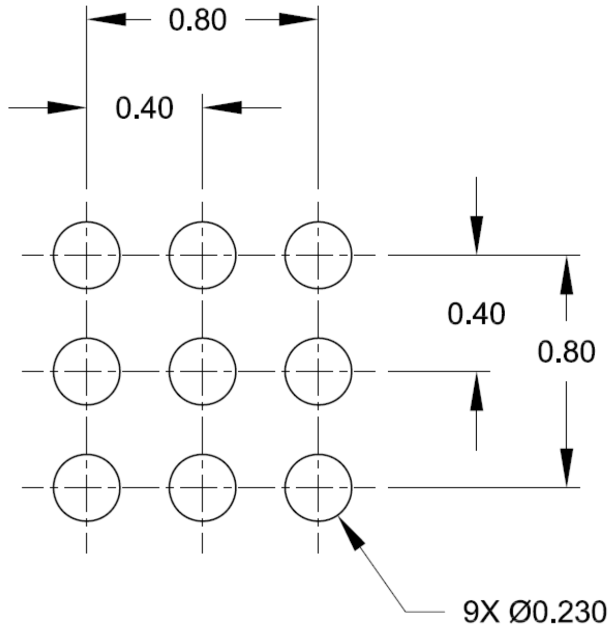


Figure 29: Outline Drawing

10.2 Land Pattern



NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS
2. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.

Figure 30: Land Pattern

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