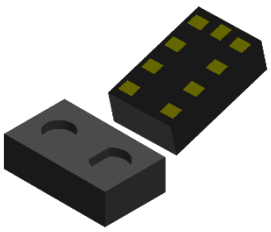
IQS622 Datasheet

Combination sensor with ambient light sensing (ALS), active IR, Hall-effect and two-channel capacitive proximity/touch sensor

The IQS622 ProxFusion™ IC is a multifunctional ambient light sensing (ALS), active IR, capacitive & Hall-effect sensor designed for applications where any or all of the technologies may be required. The IQS622 is an ultra-low power solution designed for short or long term activations through any of the sensing channels. The IQS622 is fully I²C compatible and can be configured to operate on an event mode basis to wake-up on dedicated sensors.

Features

- **Unique combination of sensing technologies:**
  - Capacitive sensing
  - Ambient light sensing (ALS)
  - Active IR proximity sensor
  - Hall-effect sensing
- **Capacitive sensing**
  - 2pF to 200pF external capacitive load capability
  - Fully adjustable sensing options
- **Ambient light sensing (ALS)**
  - 4-bit ALS range output (0 - 10)
- **Active IR proximity sensor**
  - 60mm range
  - Pulsed LED current for lower power
  - 2 Level detection with hysteresis
- **Hall-effect sensing**
  - No external components required
  - Dual direction Hall switch sensor
  - 2 level detection with hysteresis (widely variable)
  - Detection range 1mT – 100mT
- **Multiple integrated UI options** based on years of experience in sensing on fixed and mobile platforms:
  - Proximity / Touch
  - Proximity wake-up
  - SAR with movement and quick release
- **A**utomatic **T**uning **I**mplementation (**ATI**) – performance enhancement (10bit)
- Minimal external components
- Standard **I²C** interface (polling with sub 1ms clock stretching)
- Optional **RDY indication** for event mode operation
- **Low power consumption:** 300uA (50 Hz response, all technologies in use)**, 2.5**uA (low power mode, zoom to scanning mode with wake-up)
- **Event or Streaming mode**
- **Supply voltage: 1.8V to 3.3V**
- **Low profile DMA – 3.94 x 2.36 x 1.37 – 9-pin package**



DMA -3.94 x 2.36 x 1.37
9-pin

Representations only

Applications

- **Laptops, Notebooks, Mobile phones, Tablets**
  - On-ear detection
  - Screen brightness adjust
  - Keyboard backlight adjust
  - Smart cover detection and orientation
  - SAR
  - Touch volumes controls

Available Packages	
T_A	DMA – 3.94 x 2.36 x 1.37 – 9N
-40°C to 85°C	IQS622

Table of Contents

List of abbreviations

ATI – Automatic Tuning Implementation

LTA – Long term average

ALS – Ambient Light Sensing

UI – User interface

AC – Alternating current

DSP – Digital signal processing

RX – Receiving electrode

TX – Transmitting electrode

CS – Sampling capacitor

Proj – Projected

NP – Normal power

LP – Low power

ULP – Ultra low power

ACK – I^2C Acknowledge condition

NACK – I^2C Not Acknowledge condition

1 Introduction

1.1 ProxFusion™

The ProxFusion™ sensor series provide all of the proven ProxSense® engine capabilities with additional sensors types. A combined sensor solution is available within a single platform.

1.2 Packaging and Pin-Out

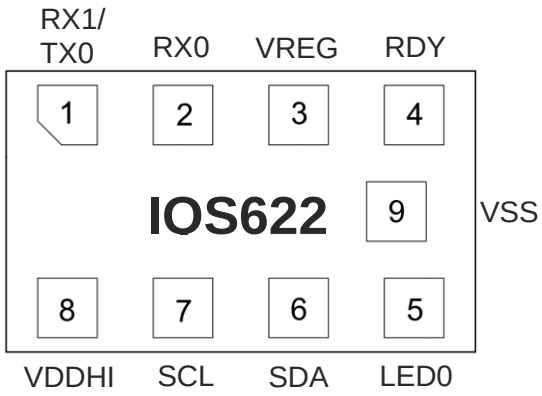


Figure 1.1 IQS622 pin-out (DMA 3.94x2.36x1.37 – 9-pin package; device markings not realistic)

Table 1.1 Pin-out description

IQS622 in DMA 3.94 x 2.36 x 1.37 – 9-pin			
Pin	**Name**	**Type**	**Function**
1	RX1/TX0	Receiving electrode / Transmitter electrode	Connect to conductive area intended for sensor receiving / transmitting
2	RX0	Receiving electrode	Connect to conductive area intended for sensor receiving
3	VREG	Regulator output	Requires external capacitor
4	RDY	Digital Input / Output	**RDY** (I^2C Ready interrupt signal)
5	LED0	Internal LED anode	Connect to voltage supply with serial current limiting resistor.
6	SDA	Digital Input / Output	**SDA** (I^2C Data signal)
7	SCL	Digital Input / Output	**SCL** (I^2C Clock signal)
8	VDDHI	Supply Input	Supply: 1.8V – 3.3V
9	VSS	Signal GND	Common ground reference

1.3 Reference schematic

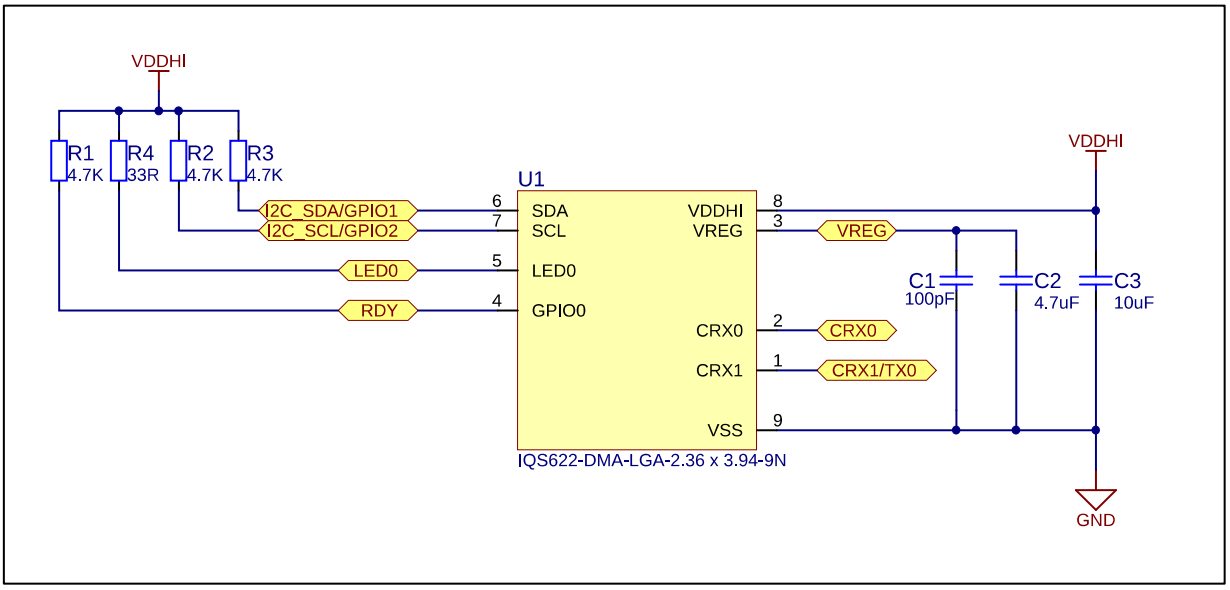


Figure 1.2 IQS622 reference schematic

1.4 Sensor channel combinations

The table below summarizes the IQS622's sensor and channel associations.

Table 1.2 Sensor channel allocation

	Sensor/UI type	CH0	CH1	CH2	CH3	CH4	CH5	CH6
Capacitive	Self / Projected	○	○					
	SAR UI	● Main	● Movement					
ALS	Ambient light sensing			●				
IR	Active Infra-Red				●	●		
Hall-effect	Hall-effect switch UI						● Positive	● Negative

Key:

○ - Optional implementation

● - Fixed use for UI

2 Capacitive sensing

2.1 Introduction to ProxSense®

Building on the previous successes from the ProxSense® range of capacitive sensors, the same fundamental sensor engine have been implemented in the ProxFusion™ series.

The capacitive sensing capabilities of the IQS622 include:

- Self and projected capacitive sensing.
- Maximum of 2 capacitive channels to be individually configured.
  - Prox and touch adjustable thresholds
  - Individual sensitivity setups
  - Alternative ATI modes
- Enhanced SAR user interface:
  - For passing the SAR qualification
  - Movement sensing to distinguish between stationary in-contact objects and human interference
  - Quick release feature (fully customizable)
- Discreet button UI:
  - Fully configurable 2 level threshold setup – Traditional Prox & Touch activation levels.
  - Customizable filter halt time

2.2 Channel specifications

The IQS622 provides a maximum of 2 channels available to be configured for capacitive sensing. Each channel can be setup separately according to the channel's associated settings registers.

There are two distinct capacitive user interfaces available to be used.

a) Self/projected capacitive proximity/touch UI (always enabled)

b) SAR UI

When the SAR UI is activated (ProxFusion settings4: bit7):

- Channel 0 is used for as the main capacitive sensing channel for SAR detection.
- Channel 1 is used for capacitive movement detection. This is used to improve the SAR detection such as quick release detection.

Table 2.1 Capacitive sensing - channel allocation

Mode	CH0	CH1	CH2	CH3	CH4	CH5	CH6
Self / Projected	○	○					
SAR UI	• Main	• Movement					

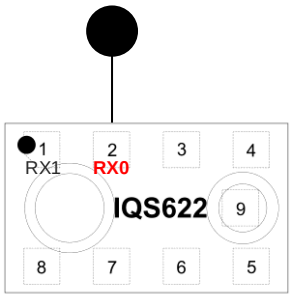
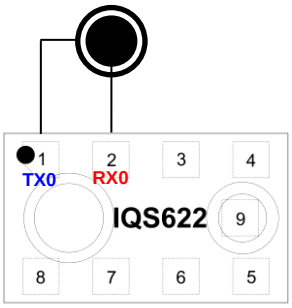
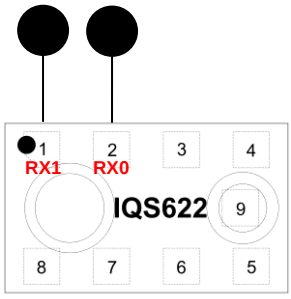
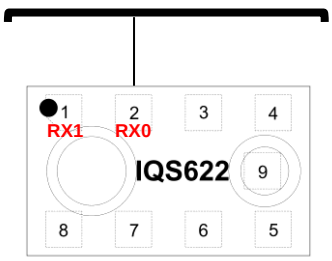
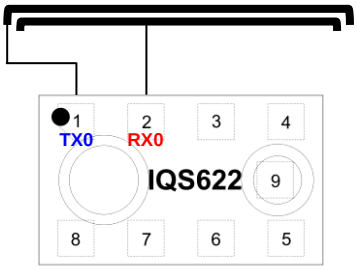
Key:

○ - Optional implementation
• - Fixed use for UI

2.3 Hardware configuration

In the table below are multiple options of configuring sensing (Rx) and transmitting (Tx) electrodes to realize different implementations (combinations not shown).

Table 2.2 Capacitive sensing - hardware description

	Self capacitive	Projected capacitive
1 button		
2 buttons		
SAR antenna		

2.4 Software configuration

To be completed.

2.5 Sensor data output and flags

The following registers should be monitored by the master to detect capacitive sensor output and SAR activations.

a) The **Global events register (0x11)** will show the IQS622's main events. Bit0 is dedicated to the ProxSense activations and bit1 is allocated to show SAR events. SAR_EVENT (bit1) will toggle upon each SAR qualified event.

Global events (0x11)								
Bit Number	7	6	5	4	3	2	**1**	**0**
Data Access	-	R	R	R	R	R	**R**	**R**
Name	-	POWER MODE EVENT	SYS EVENT	ACTIVE IR EVENT	ALS EVENT	HALL EVENT	**SAR EVENT**	**PROX SENSE EVENT**

b) The **ProxSense UI flags (0x12)** and **SAR UI flags (0x13)** provide more detail regarding the outputs. A prox and touch output bit for each channel 0 to 3 is provided in the ProxSense UI Flags register.

c) The **SAR UI flags (0x13)** register will show detail regarding the state of the SAR output (**SAR ACTIVE**) as well as quick release toggles, movement activations and the state of the filter (halted or not).

ProxSense UI flags (0x12)								
Bit Number	7	6	**5**	**4**	3	2	**1**	**0**
Data Access	-	-	**R**	**R**	-	-	**R**	**R**
Name	**-**	**-**	**CH1_T**	**CH0_T**	**-**	**-**	**CH1_P**	**CH0_P**
SAR UI flags (0x13)								
Bit Number	7	6	5	**4**	**3**	**2**	**1**	**0**
Data Access	-	-	-	**R**	**R**	**R**	**R**	**R**
Name	-	-	-	**SAR ACTIVE**	**HAND HELD MODE**	**QUICK RELEASE**	**MOVE-MENT**	**FHALT**

3 Ambient light sensing (ALS)

3.1 Introduction to ambient light sensing

The IQS622 employs two light sensitive semi-conductor areas on chip to realise an ambient light sensor. The sensor capabilities includes:

- 4-bit ALS value output (0 – 10).

3.2 Channel specifications

The IQS622 provides 2 dedicated channels to ALS conversions.

Table 3.1 Ambient light sensing - channel allocation

Mode	CH0	CH1	CH2	CH3	CH4	CH5	CH6
ALS			●				

Key:

○ - Optional implementation

● - Fixed use for UI

Please note:

- CS size, multipliers and charge frequency are adjustable.
- Counts on these channels are limited to 8000 counts.
- **Ch2 – ALS channel 1:**
  - Assigned to narrow spectrum ALS

3.3 Hardware configuration

To be completed.

3.4 Software configuration

To be completed.

3.5 Sensor data output and flags

The following registers can be monitored by the master to detect ALS related events.

a) The **ALS EVENT (bit 3)** in the **Global events (0x11)** register are dedicated to ALS related events. This bit will toggle when the ALS value change in any direction. The ALS event bit will automatically clear by reading the **Global events (0x11)** register.

Global events (0x11)								
Bit Number	7	6	5	4	**3**	2	1	0
Data Access	-	R	R	R	**R**	R	R	R
Name	-	POWER MODE EVENT	SYS EVENT	ACTIVE IR EVENT	**ALS EVENT**	HALL EVENT	SAR EVENT	PROX SENSE EVENT

b) The **ALS UI flags (0x14)** register provides a 4 bit ALS value to indicate the magnitude of the current ALS reading **(ALS range value bit 0-3)**. The ALS value ranges from 0 to 10.

ALS UI flags (0x14)								
Bit Number	7	6	5	4	**3**	**2**	**1**	**0**
Data Access	-				**R**	**R**	**R**	**R**
Name	Reserved				**ALS range value**			

4 Active Infra-Red (IR)

4.1 Introduction to active IR sensing

The IQS622 employs two light sensitive semi-conductor areas to realise an active IR sensor. The sensor capabilities includes:

- 60mm detection range
- Pulsed LED current for lower power
- Two threshold levels are provided
- Proximity/Touch indication provided.

4.2 Channel specifications

The IQS622 provides 2 dedicated channels to IR conversions.

Table 4.1 Active IR sensing - channel allocation

Mode	CH0	CH1	CH2	CH3	CH4	CH5	CH6
Active IR				•	•		

Key:

○ - Optional implementation

● - Fixed use for UI

Please note:

- CS size, multipliers and charge frequency divider are adjustable.
- Counts on these channels are limited to 8000 counts
- **Ch3 – IR channel 1:**
  - Assigned to wide spectrum ALS
  - LED driver inactive
- **Ch4 – IR channel 2:**
  - Assigned to wide spectrum ALS
  - LED driver active

4.3 Hardware configuration

To be completed.

4.4 Software configuration

To be completed.

4.5 Sensor data output and flags

The following registers can be monitored by the master to detect active IR related events.

c) The **ACTIVE_IR_EVENT (bit 2)** in the **Global events (0x11)** register are dedicated to Active IR related events. This bit will toggle when the IR prox flag is set and is automatically cleared after reading the register.

Global events (0x11)								
Bit Number	7	6	5	**4**	3	2	1	0
Data Access	-	R	R	**R**	R	R	R	R
Name	-	POWER MODE EVENT	SYS EVENT	**ACTIVE IR EVENT**	ALS EVENT	HALL EVENT	SAR EVENT	PROX SENSE EVENT

d) The **Active IR UI flags (0x15)** register provides a classic two level prox/touch activation (**ACTIVE_IR_POUT** & **ACTIVE_IR_TOUT**). The thresholds for both are fully configurable in registers 0x91 and 0x92.

Active IR UI flags (0x15)								
Bit Number	7	6	5	4	3	2	**1**	**0**
Data Access	-	-	-	-	-	-	**R**	**R**
Name	-	-	-	-	-	-	**ACTIVE IR TOUT**	**ACTIVE IR POUT**

e) The **Active IR UI output (0x16 - 0x17)** registers provide a 16 bit value of the Active IR output magnitude as obtained by the current sensor measurement.

Active IR UI output (0x16 - 0x17)								
Bit Number	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data Access	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**
Name	**Active IR UI output low byte**							
Bit Number	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**
Data Access	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**
Name	**Active IR UI output high byte**							

5 Hall-effect sensing

5.1 Introduction to Hall-effect sensing

The IQS622 has two internal Hall-effect sensing plates (on chip). No external sensing hardware is required for Hall-effect sensing.

The Hall-effect measurement is essentially a current measurement of the induced current through the Hall-effect-sensor plates produced by the magnetic field passing perpendicular through each plate.

Advanced digital signal processing are performed to provide sensible output data.

- Two threshold levels are provided (proximity & touch).
- Hall-effect output is linearized by inverting signals.
- North/South field direction indication provided.
- Differential Hall-Effect sensing:
    - Removes common mode disturbances
    - North-South field indication

5.2 Channel specifications

Channels 5 and 6 are dedicated to Hall-effect sensing. Channel 5 performs the positive direction measurements and channel 6 will handle all measurements in the negative direction. These two channels are used in conjunction to acquire differential Hall-effect data and will always be used as input data to the Hall-effect UI's.

There is a dedicated Hall-effect user interface available:

a) Hall-effect switch UI

Table 5.1 Hall-effect sensor – channel allocation

Mode	CH0	CH1	CH2	CH3	CH4	CH5	CH6
Hall-effect switch UI						● Positive	● Negative

Key:

○ - Optional implementation

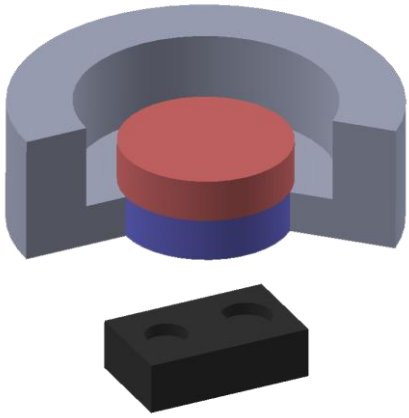
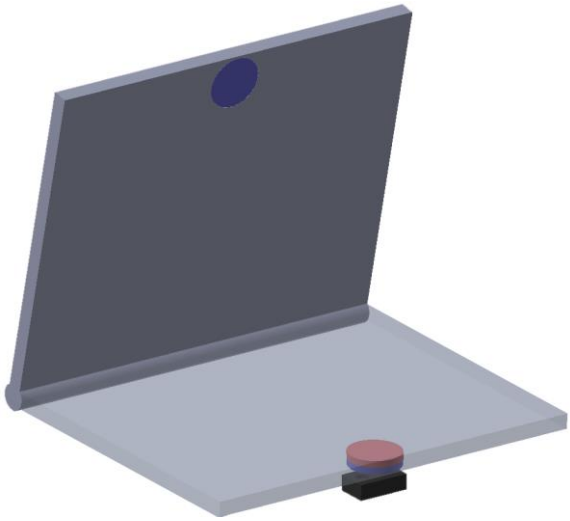
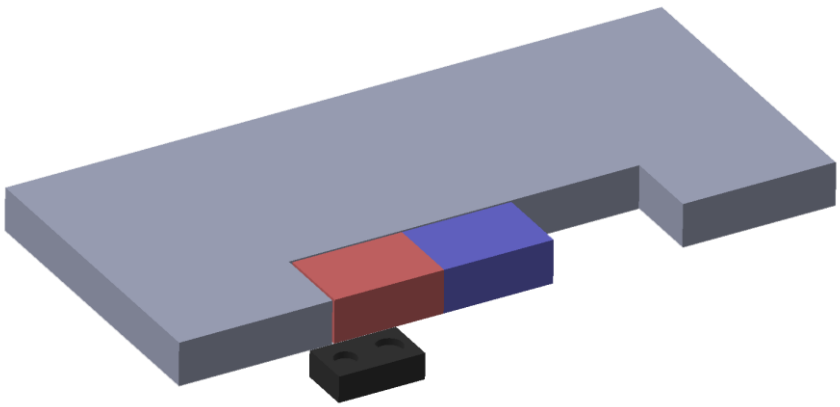
● - Fixed use for UI

- Large CS cap is always used
- Charge frequency is selectable.
- **Ch5 – Hall-effect channel 1:**
    - Hall 0(CRx0 bit set) is sensing without polarity flip.
- **Ch6 – Hall-effect channel 2:**
    - Hall 0(CRx0 bit set) is sensing with polarity flip.

5.3 Hardware configuration

Rudimentary hardware configurations.

Table 5.2 Hall-effect sensing – hardware description

	Axially polarized magnet (linear movement or magnet presence detection)
Hall-effect push switch	
Smart cover	
	Bar magnet (linear movement and magnet field detection)
Slide switch	

Software configuration

To be completed.

5.4 Sensor data output and flags

The following registers can be monitored by the master to detect Hall-effect related events.

f) The **HALL_EVENT (bit 1)** in the **Global events (0x11)** register are dedicated to Hall-effect related events. This bit will toggle when either one of the three Hall-effect flags is set and is automatically cleared after reading the registers.

Global events (0x11)								
Bit Number	7	6	5	4	3	**2**	1	0
Data Access	-	R	R	R	R	**R**	R	R
Name	-	POWER MODE EVENT	SYS EVENT	ACTIVE IR EVENT	ALS EVENT	**HALL EVENT**	SAR EVENT	PROX SENSE EVENT

g) The **Hall-effect UI flags (0x18)** register provides the standard two level activation output (prox = **HALL_POUT** & touch = **HALL_TOUT**) as well as a **HALL_N/S** bit to indicate the magnet polarity orientation.

Hall-effect UI flags (0x18)								
Bit Number	7	6	5	4	3	**2**	**1**	**0**
Data Access	-	-	-	-	-	**R**	**R**	**R**
Name	-	-	-	-	-	**HALL TOUT**	**HALL POUT**	**HALL N/S**

h) The **Hall-effect UI output (0x19 - 0x1A)** registers provide a 16 bit value of the Hall-effect amplitude detected by the sensor.

Hall-effect UI output (0x19- 0x1A)								
Bit Number	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data Access	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**
Name	**Hall-effect UI output low byte**							
Bit Number	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**
Data Access	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**
Name	**Hall-effect UI output high byte**							

6 Device clock, power management and mode operation

6.1 Device main oscillator

The IQS622 has a **16MHz** main oscillator (default enabled) to clock all system functionality.

An option exists to reduce the main oscillator to 8MHz. This will result in all system timings, charge transfers and sample rates to be slower by half of the default implementations.

To set this option this:

- As a software setting – Set the System_settings: bit4 = 1, via an I^2C command.
- As a permanent setting – Set the OTP option in FG Bank 0: bit2 = 1, using Azoteq USBProg program.

6.2 Device modes

The IQS622 supports the following modes of operation;

- **Normal power mode** (Fixed report rate)
- **Low power mode** (Reduced report rate, no UI execution)
- **Ultra-low power mode** (Only channel 0 is sensed for a prox)
- **Halt mode** (Suspended/disabled)
  Note: Auto modes must be disabled to enter or exit halt mode.

The device will automatically switch between the different operating modes by default. However this Auto mode feature may be disabled by setting the DSBL_AUTO_MODE bit (Power _mode_settings 0xD2: bit5) to confine device operation to a specific power mode. The POWER_MODE bits (Power_mode_settings 0xD2: bit4-3) can then be used to specify the desired mode of operation.

6.2.1 Normal mode

Normal mode is the fully active sensing mode to function at a fixed report rate specified in the Normal power mode report rate (0xD3) register. This 8-bit value is adjustable from 0ms – 255ms in intervals of 1ms.

Note: The device's low power oscillator have an accuracy as specified in section 9.

6.2.2 Low power mode

Low power mode is a reduced sensing mode where all channels are sensed but no UI code are executed. The sample rate can be specified in the Low power mode report rate (0xD4) register. The 8-bit value is adjustable from 0ms – 255ms in intervals of 1ms. Reduced report rates also reduce the current consumed by the sensor.

Note: The device's low power oscillator have an accuracy as specified in section 9.

6.2.3 Ultra-low power mode

Ultra-low power mode is a reduced sensing mode where only channel 0 is sensed and no other channels or UI code are executed. Set the EN_ULP_MDE bit (Power_mode_settings: bit6) to enable use of the ultra-low power mode. The sample rate can be specified in the Low power mode report rate (0xD5) register. The 8-bit value is adjustable from 0ms – 4sec in intervals of 16ms.

Wake up will occur on prox detection on channel 0.

6.2.4 Halt mode

Halt mode will suspend all sensing and will place the device in a dormant or sleep state. The device requires an I^2C command from a master to explicitly change the power mode out of the halt state before any sensor functionality can continue.

6.2.5 Mode time

The mode time is specified in the Auto mode timer (0xD6) register. The 8-bit value is adjustable from 0ms – 2 min in intervals of 500ms.

6.3 Report rates

6.3.1 Calculation of each mode's report rate

Normal power segment rate

To be completed.

Auto modes change rates

To be completed.

Streaming/event mode rates

To be completed.

6.4 System reset

The IQS622 device monitor's system resets and events.

a) Every device power-on and reset event will set the Show Reset bit (System flags 0x10: bit7) and the master should explicitly clear this bit by writing it active to acknowledge a valid reset.

b) The system events will also be indicated with the Global events register's SYS bit (Global events 0x11: bit5) if any system event occur such as a reset. This event will continuously trigger until the reset has been acknowledged.

7 Communication

7.1 I²C module specification

The device supports a standard two wire I²C interface with the addition of an RDY (ready interrupt) line. The communications interface of the IQS622 supports the following:

- Streaming data as well as event mode.
- The master may address the device at any time. If the IQS622 is not in a communication window, the device will return an ACK after which clock stretching may be induced until a communication window is entered. Additional communication checks are included in the main loop in order to reduce the average clock stretching time.
- The provided interrupt line (RDY) is open-drain active low implementation and indicates a communication window.

7.2 Device address and sub-addresses

The default device address is **0x44 = DEFAULT_ADDR**.
Alternative sub-address options are definable in the following one-time programmable bits: **OTP Bank0 (bit3; 0; bit1; bit0) = SUB_ADDR_0** to **SUB_ADDR_7**

a) Default address: **0x44** = **DEFAULT_ADDR** OR **SUB_ADDR_0**
b) Sub-address: **0x45** = **DEFAULT_ADDR** OR **SUB_ADDR_1**
c) Sub-address: **0x46** = **DEFAULT_ADDR** OR **SUB_ADDR_2**
d) Sub-address: **0x47** = **DEFAULT_ADDR** OR **SUB_ADDR_3**
e) Sub-address: **0x4C** = **DEFAULT_ADDR** OR **SUB_ADDR_4**
f) Sub-address: **0x4D** = **DEFAULT_ADDR** OR **SUB_ADDR_5**
g) Sub-address: **0x4E** = **DEFAULT_ADDR** OR **SUB_ADDR_6**
h) Sub-address: **0x4F** = **DEFAULT_ADDR** OR **SUB_ADDR_7**

7.3 Additional OTP options

All one-time-programmable device options are located in OTP bank0.

OTP bank0								
Bit Number	7	6	5	4	3	2	1	0
Name	Internal use	COMMS ATI	IR INC DELAY	ALS INC DELAY	SUB ADDRESS (bit3)	8MHz	SUB ADDRESS (bit1-0)	

Bit definitions:

- Bit7: Internal use
  - Do not set. Leave bit cleared.
- Bit 6: Communication mode during ATI
  - 0: No streaming events are generated during ATI
  - 1: Communication continue as setup regardless of ATI state.
- Bit 5: IR increment delay
  - 0: No delay increment
  - 1: Increment delay implemented
- Bit4: ALS increment delay
  - 0: No delay increment
  - 1: Increment delay implemented
- Bit 2: Main Clock frequency selection
  - 0: Run FOSC at 16MHz
  - 1: Run FOSC at 8MHz
- Bit 3,1,0: I2C sub-address
  - I2C address = 0x44 OR SUB_ADDR

7.4 Recommended communication and runtime flow diagram

The following is a basic master program flow diagram to communicate and handle the device. It addresses possible device events such as output events, ATI and system events (resets).

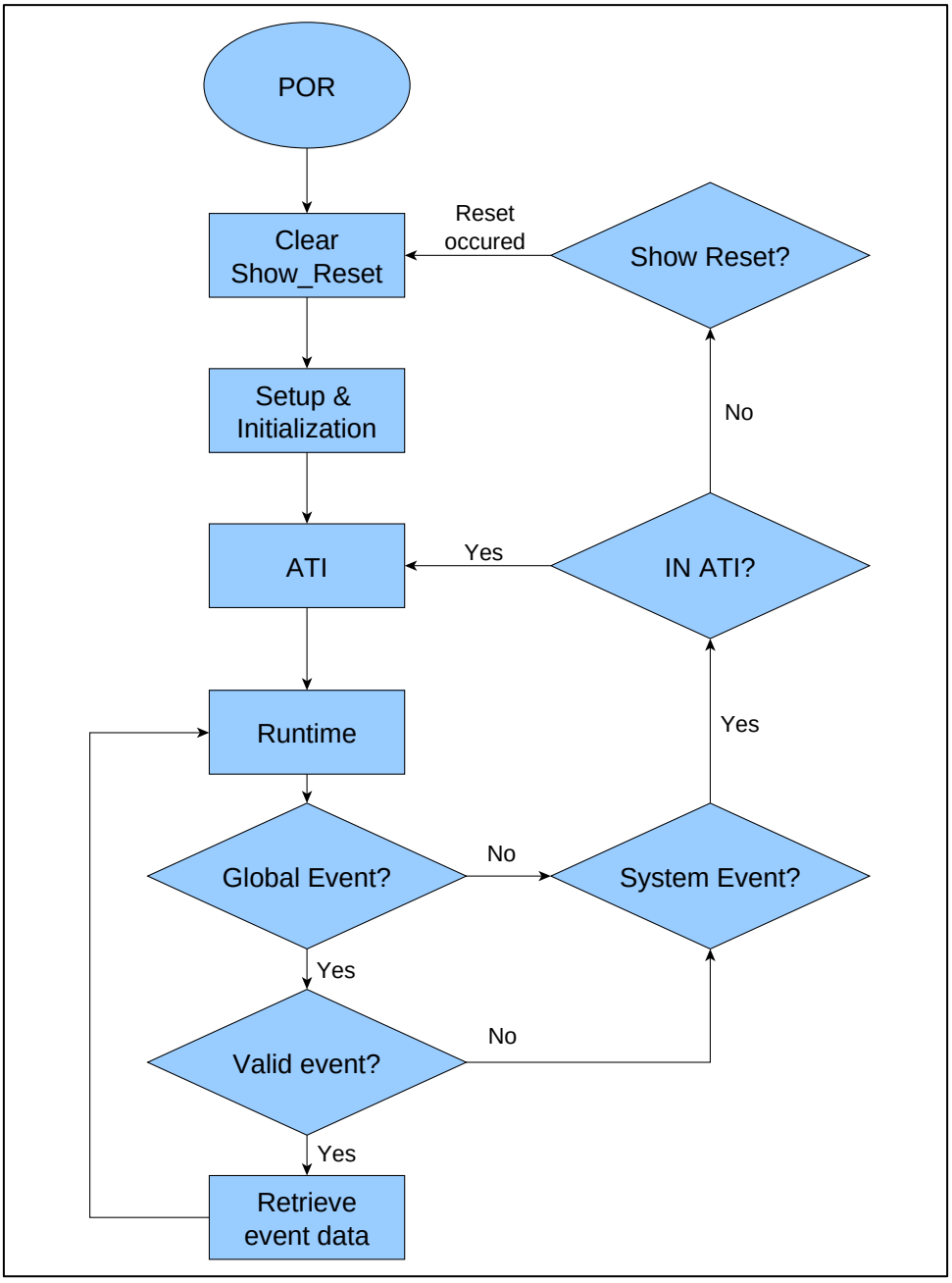


Figure 7.1 Master command structure and runtime event handling flow diagram

It is recommended that the master verifies the status of the System_flags bits to identify events and resets. Detecting either one of these should prompt the master to the next steps of handling the IQS622.

Streaming mode communication is used for detail sensor evaluation during prototyping and/or development phases.

Event mode communication is recommended for runtime use of the IQS622. This reduce the communication on the I^2C bus and report only triggered events.

8 Memory map

The full memory map is summarized below. Register groups are explained in the latter subsections.

Table 8.1 IQS622 Memory map index

Full Address	Group Name	Item Name	Data Access
0x00	Device information data	Product number	Read-Only
0x01		Software number	Read-Only
0x02		Hardware number	Read-Only
0x10	Flags and user interface data	System flags	Read-Only
0x11		Global events	Read-Only
0x12		ProxSense UI flags	Read-Only
0x13		SAR UI flags	Read-Only
0x14		ALS UI flags	Read-Only
0x15		Active IR UI flags	Read-Only
0x16		Active IR UI output 0	Read-Only
0x17		Active IR UI output 1	Read-Only
0x18		Hall-effect UI flags	Read-Only
0x19		Hall-effect UI output 0	Read-Only
0x1A		Hall-effect UI output 1	Read-Only
0x20	Channel counts (raw data)	Counts Channel 0 low	Read-Only
0x21		Counts Channel 0 high	Read-Only
0x22		Counts Channel 1 low	Read-Only
0x23		Counts Channel 1 high	Read-Only
0x24		Counts Channel 2 low	Read-Only
0x25		Counts Channel 2 high	Read-Only
0x26		Counts Channel 3 low	Read-Only
0x27		Counts Channel 3 high	Read-Only
0x28		Counts Channel 4 low	Read-Only
0x29		Counts Channel 4 high	Read-Only
0x2A		Counts Channel 5 low	Read-Only
0x2B		Counts Channel 5 high	Read-Only
0x2C		Counts Channel 6 low	Read-Only
0x2D		Counts Channel 6 high	Read-Only
0x30	LTA values (filtered data)	LTA Channel 0 low	Read-Only
0x31		LTA Channel 0 high	Read-Only
0x32		LTA Channel 1 low	Read-Only
0x33		LTA Channel 1 high	Read-Only
0x40	ProxFusion sensor settings	ProxFusion settings 0_0	Read-Write
0x41		ProxFusion settings 0_1	Read-Write
0x42		ProxFusion settings 1_0	Read-Write
0x43		ProxFusion settings 1_1	Read-Write
0x44		ProxFusion settings 2_0	Read-Write
0x45		ProxFusion settings 2_1	Read-Write
0x46		ProxFusion settings 3_0	Read-Write
0x47		ProxFusion settings 3_1	Read-Write
0x48		ProxFusion settings 4	Read-Write
0x49		ProxFusion settings 5	Read-Write

0x4A		Compensation Ch0	Read-Write
0x4B		Compensation Ch1	Read-Write
0x4C		Multipliers Ch0	Read-Write
0x4D		Multipliers Ch1	Read-Write
0x50	ProxFusion UI settings	Prox threshold Ch0	Read-Write
0x51		Touch threshold Ch0	Read-Write
0x52		Prox threshold Ch1	Read-Write
0x53		Touch threshold Ch1	Read-Write
0x54		ProxFusion discrete UI halt time	Read-Write
0x60	SAR UI settings	SAR UI settings 0	Read-Write
0x61		SAR UI settings 1	Read-Write
0x62		QRD threshold Ch0	Read-Write
0x63		Filter halt threshold Ch0	Read-Write
0x64		Prox threshold Ch0	Read-Write
0x65		QRD halt time	Read-Write
0x70	Light sensor settings	ALS settings 0	Read-Write
0x71		ALS settings 1	Read-Write
0x72		IR settings 0	Read-Write
0x73		IR settings 1	Read-Write
0x74		Multipliers Ch2	Read-Write
0x75		Multipliers Ch3,4	Read-Write
0x90	Active IR UI settings	Active IR UI settings	Read-Write
0x91		Active IR UI prox threshold	Read-Write
0x92		Active IR UI touch threshold	Read-Write
0xA0	Hall-effect sensor settings	Hall-effect settings 0	Read-Write
0xA1		Hall-effect settings 1	Read-Write
0xA2		Compensation Ch5,6	Read-Write
0xA3		Multipliers Ch5,6	Read-Write
0xB0	Hall-effect switch UI settings	Hall-effect switch UI settings	Read-Write
0xB1		Hall-effect switch UI prox threshold	Read-Write
0xB2		Hall-effect switch UI touch threshold	Read-Write
0xD0	Device and power mode settings	System settings	Read-Write
0xD1		Active channels	Read-Write
0xD2		Power mode settings	Read-Write
0xD3		Normal power mode report rate	Read-Write
0xD4		Low power mode report rate	Read-Write
0xD5		Ultra-low power mode report rate	Read-Write
0xD6		Auto mode timer	Read-Write

8.2 Device Information data

8.2.1 Product number

Product number (0x00)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	Device product number							

Bit definitions:

- Bit 7-0: Device product number = D’66’

8.2.2 Software number

Software number (0x01)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	Device software number							

Bit definitions:

- Bit 7-0: Device software number = D’06’

8.2.3 Hardware number

Hardware number (0x02)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	Device hardware number							

Bit definitions:

- Bit 7-0: Device hardware number = D’131’

8.3 Flags and user interface data

8.3.1 System flags

System flags (0x10)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	-	-	R	R	R	R	R
Name	SHOW RESET	-	-	POWER MODE		IN ATI	EVENT	NP SEG ACTIVE

Bit definitions:

- Bit 7: Reset indicator
  - 0: No reset event
  - 1: A device reset has occurred and needs to be acknowledged.
- Bit 3-4: Current power mode indicator
  - 00: Normal Mode
  - 01: Low Power Mode
  - 10: Ultra-Low Power Mode
  - 11: Halt Mode
- Bit 2: ATI busy indicator
  - 0: No channels are in ATI
  - 1: One or more channels are in ATI
- Bit 1: Global event indicator
  - 0: No new event to service
  - 1: An event has occurred and should be serviced
- Bit 0: Normal power segment indicator
  - 0: Not performing a normal power update
  - 1: Busy performing a normal power update

8.3.2 Global events

Global events (0x11)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	R	R	R	R	R	R	R
Name	-	POWER MODE EVENT	SYS EVENT	ACTV IR EVENT	ALS EVENT	HALL EVENT	SAR EVENT	PROX SENSE EVENT

Bit definitions:

- Bit 6: Power mode event flag
  - 0: No event to report
  - 1: A power mode event has occurred and should be handled
- Bit 5: System event flag
  - 0: No event to report
  - 1: A system event has occurred and should be handled
- Bit 4: Active IR event flag
  - 0: No event to report
  - 1: An active IR event has occurred and should be handled

- Bit 3: ALS detect event flag
  - 0: No event to report
  - 1: An ALS detect event has occurred and should be handled
- Bit 2: Hall-effect event flag
  - 0: No event to report
  - 1: A Hall-effect event has occurred and should be handled
- Bit 1: SAR event flag
  - 0: No event to report
  - 1: A SAR event has occurred and should be handled
- Bit 0: ProxSense event flag
  - 0: No event to report
  - 1: A capacitive key event has occurred and should be handled

8.3.3 ProxSense UI flags

ProxSense UI flags (0x12)								
Bit Number	-	-	5	4	-	-	1	0
Data Access	-	-	R	R	-	-	R	R
Name	-	-	CH1_T	CH0_T	-	-	CH1_P	CH0_P

Bit definitions:

- Bit 5: Ch1 touch indicator
  - 0: Delta below touch level
  - 1: Delta above touch level
- Bit 4: Ch0 touch indicator
  - 0: Delta below touch level
  - 1: Delta above touch level
- Bit 1: Ch1 proximity indicator
  - 0: Delta below proximity level
  - 1: Delta above proximity level
- Bit 0: Ch0 proximity indicator
  - 0: Delta below proximity level
  - 1: Delta above proximity level

8.3.4 SAR UI flags

SAR UI flags (0x13)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	-	-	R	-	R	R	R
Name	-	-	-	SAR ACTIVE		QUICK RELEASE	MOVE-MENT	FHALT

Bit definitions:

- Bit 4: SAR Standoff Active
  - 0: Delta below SAR threshold level
  - 1: Delta above SAR threshold level
- Bit 2: Quick release detection indicator

- 0: Quick release not detected
- 1: Quick release detected

- Bit 1: Movement indicator
  - 0: Movement not detected
  - 1: Movement detected
- Bit 0: Filter halt indicator
  - 0: Delta below filter halt level
  - 1: Delta above filter halt level

8.3.5 ALS UI flags

ALS UI flags (0x14)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	-	-	-	R	R	R	R
Name	-	Reserved			ALS range value			

Bit definitions:

- Bit 3-0: ALS range value

8.3.6 Active IR UI flags

Active IR UI flags (0x15)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	-	-	-	-	-	R	R
Name	-	-	-	-	-	-	TOUCH	PROX

Bit definitions:

- Bit 1: Active IR touch indicator
  - 0: Field strength below touch level
  - 1: Field strength above touch level
- Bit 0: Active IR proximity indicator
  - 0: Field strength below proximity level
  - 1: Field strength above proximity level

8.3.7 Active IR UI output

Active IR UI output (0x16/0x17)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	Active IR UI output low byte							
Bit Number	15	14	13	12	11	10	9	8
Data Access	R	R	R	R	R	R	R	R
Name	Active IR UI output high byte							

Bit definitions:

- Bit 15-0: Active IR UI output

8.3.8 Hall-effect UI flags

Hall-effect UI flags (0x18)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	-	-	-	-	R	R	R
Name	-	-	-	-	-	TOUCH	PROX	HALL N/S

Bit definitions:

- Bit 2: Hall-effect touch indicator
  - 0: Field strength below touch level
  - 1: Field strength above touch level
- Bit 1: Hall-effect proximity indicator
  - 0: Field strength below proximity level
  - 1: Field strength above proximity level
- Bit 0: Hall-effect North South field indication
  - 0: North field present
  - 1: South field present

8.3.9 Hall-effect UI output

Hall-effect UI output (0x19 - 0x1A)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	Hall-effect UI output low byte							
Bit Number	15	14	13	12	11	10	9	8
Data Access	R	R	R	R	R	R	R	R
Name	Hall-effect UI output high byte							

Bit definitions:

- Bit 15-0: Hall-effect UI output

8.4 Channel counts (raw data)

Channel counts Ch0/1/2/3/4/5/6 (0x20/0x21-0x2C/0x2D)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	Channel counts low byte							
Bit Number	15	14	13	12	11	10	9	8
Data Access	R	R	R	R	R	R	R	R
Name	Channel counts high byte							

Bit definitions:

- Bit 15-0: AC filter or raw value

8.5 LTA values (filtered data)

LTA Ch0/1 (0x30/0x31-0x32/0x33)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	LTA low byte							
Bit Number	15	14	13	12	11	10	9	8
Data Access	R	R	R	R	R	R	R	R
Name	LTA high byte							

Bit definitions:

- Bit 15-0: LTA filter value

8.6 ProxFusion sensor settings

8.6.1 ProxFusion settings 0

8.6.1.1 Capacitive sensing

ProxFusion settings 0_0/1 (0x40-0x41)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	-	R/W	R/W	R/W	R/W	R/W
Name	Sensor mode		-	PROJ / SELF	TX Select		RX Select	
Fixed value	0	0						

Bit definitions:

- Bit 7-6: Sensor Mode
  - 00: ProxSense mode
- Bit 4: PROJ/SELF
  - 0: Self-capacitive mode is used
  - 1: Projected-capacitive mode is used
- Bit 3-2: TX Select
  - 00: TX 0 and TX 1 is disabled
  - 01: TX 0 is enabled
  - 10: TX 1 is enabled
  - 11: TX 0 and TX 1 is enabled
- Bit 1-0: RX Select
  - 00: RX 0 and RX 1 is disabled
  - 01: RX 0 is enabled
  - 10: RX 1 is enabled
  - 11: RX 0 and RX 1 is enabled

8.6.2 ProxFusion settings 1

8.6.2.1 Capacitive sensing

ProxFusion settings 1_0/1 (0x42-0x43)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	-	CSz	CHARGE FREQ		PROJ BIAS		AUTO_ATI_MODE	

Bit definitions:

- Bit 6: CS size
  - 0: Prox storage capacitor size is 15pF
  - 1: Prox storage capacitor size is 60pF
- Bit 5-4: Charge frequency divider
  - 00: 1/2
  - 01: 1/4
  - 10: 1/8
  - 11: 1/16

- Bit 3-2: Projected bias
  - 00: 2.5µA
  - 01: 5µA
  - 10: 10µA
  - 11: 20µA
- Bit 1-0: Auto ATI Mode
  - 00: ATI disabled
  - 01: Partial ATI (all multipliers are fixed)
  - 10: Semi-Partial ATI (only coarse multipliers are fixed)
  - 11: Full-ATI

8.6.3 ProxFusion settings 2

8.6.3.1 Capacitive sensing

ProxFusion settings 2_0/1 (0x44-0x45)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	ATI_BASE		ATI_TARGET (x32)					

Bit definitions:

- Bit 7-6: Auto ATI base value
  - 00: 75
  - 01: 100
  - 10: 150
  - 11: 200
- Bit 5-0: Auto ATI Target
  - ATI Target is 6-bit value x 32

8.6.4 ProxFusion settings 3

8.6.4.1 Capacitive sensing

ProxFusion settings 3_0/1 (0x46-0x47)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	-	R/W	R/W	R/W	-
Name	UP LENGTH SELECT		CS DIV	Internal use	UP LENGTH EN	PASS LENGTH SELECT		-

Bit definitions:

- Bit 7-6: Up Length Select
  - 00: Up length = 0010
  - 01: Up length = 0110
  - 10: Up length = 1010
  - 11: Up length = 1110
- Bit 5: CS divider
  - 0: CS divider disabled
  - 1: CS divider enabled

- Bit 3: Up length increase enable
  - 0: Up length select is disabled
  - 1: Up length select is enabled (value in bit 7-6 is used)
- Bit 2-1: Pass Length Select
  - 00: Pass length = 001
  - 01: Pass length = 011
  - 10: Pass length = 101
  - 11: Pass length = 111

8.6.5 ProxFusion settings 4

8.6.5.1 Capacitive sensing

ProxFusion settings 4 (0x48)								
Bit Number	7	-	5	4	3	2	1	0
Data Access	R/W	-	R/W	R/W	R/W	R/W	R/W	R/W
Name	SAR EN	-	TWO SIDED EN	ACF DISABLE	LTA BETA		ACF BETA	

Bit definitions:

- Bit 7: SAR UI Enable
  - 0: SAR UI is disabled
  - 1: SAR UI is enabled
- Bit 5: Two Sided Detection
  - 0: Bidirectional detection disabled
  - 1: Bidirectional detection enabled
- Bit 4: Disable AC Filter
  - 0: AC Filter Enabled
  - 1: AC Filter Disabled
- Bit 3-2: Long Term Average Beta Value
  - 00: 7
  - 01: 8
  - 10: 9
  - 11: 10
- Bit 1-0: AC Filter Beta Value
  - 00: 1
  - 01: 2
  - 10: 3
  - 11: 4

8.6.6 ProxFusion settings 5

ProxFusion settings 5 (0x49)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	-	-	R/W	R/W	R/W	R/W	R/W

	Internal use

Bit definitions:

- Bit 7-0: Internal use

8.6.7 Compensation Ch0/1

Compensation Ch0/1 (0x4A-0x4B)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Compensation (0-7)							

Bit definitions:

- Bit 7-0: Compensation lower 8-bits
  - 0-255: Lower 8-bits of the compensation value.

8.6.8 Multipliers Ch0/1

Multipliers Ch0/1 (0x4C-0x4D)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	COMPENSATION (8-9)		MULTIPLIERS COARSE		MULTIPLIERS FINE			

Bit definitions:

- Bit 7-6: Compensation upper two bits
  - 0-3: Upper 2-bits of the compensation value.
- Bit 5-4: Multiplier coarse
  - 0-3: Coarse multiplier selection
- Bit 3-0: Multiplier fine
  - 0-15: Fine multiplier selection

8.7 ProxFusion UI settings

8.7.1 Prox threshold Ch0/1

Prox threshold Ch0/1 (0x50/0x52)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Proximity threshold value							

Bit definitions:

- Bit 7-0: Proximity threshold = Proximity threshold value

8.7.2 Touch threshold Ch0/1

Touch threshold Ch0/1 (0x51/0x53)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Touch Threshold Value							

Bit definitions:

- Bit 7-0: Touch threshold = Touch threshold value * LTA/ 256

8.7.3 ProxFusion discrete UI halt time

ProxFusion discrete UI halt time (0x54)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Halt time							

Bit definitions:

- Bit 7-0: Halt time in 500ms increments (decimal value x 500ms)

8.8 SAR UI settings

8.8.1 SAR setting 0

SAR settings 0 (0x60)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	R/W	R/W	R/W	-	R/W	R/W	R/W
Name	-	Quick release beta			-	Movement beta		

Bit definitions:

- Bit 6-4: Quick release detection beta
  - 0-7: Quick release detection filter beta value
- Bit 2-0: Movement detection filter beta
  - 0-7: Movement filter beta value

8.8.2 SAR settings 1

SAR settings 1 (0x61)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	LTA halt timeout in no prox				Movement detection threshold			

Bit definitions:

- Bit 7-4: LTA halt timeout in no prox
  - 0-15: LTA halt timeout in no prox in 500ms increments
- Bit 3-0: Movement detection threshold
  - 0-15: Movement threshold = Movement threshold value

8.8.3 Quick release detection threshold

Quick release detection threshold (0x62)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	QRD threshold value							

Bit definitions:

- Bit 7-0: QRD threshold = QRD threshold value

8.8.4 Filter halt threshold

Filter halt threshold (0x63)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Filter halt threshold value							

Bit definitions:

- Bit 7-0: Filter halt threshold = Filter halt threshold value

8.8.5 Proximity threshold

Proximity threshold (0x64)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Proximity threshold value							

Bit definitions:

- Bit 7-0: Proximity threshold = Proximity threshold value

8.8.6 LTA halt after a QRD

LTA halt timeout after a quick release detection (0x65)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	LTA Halt timeout after a Quick release event with no movement							

Bit definitions:

- Bit 7-0: LTA Halt timeout after a quick release detection with no movement in 500 ms increments

8.9 Light sensor settings

8.9.1 ALS settings 0

ALS settings 0 (0x70)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	-	R/W	R/W	R/W	R/W	-	-
Name	Fast Filter	Internal use	CHARGE FREQ		Inc Delay	CSz	-	-

Bit definitions:

- Bit 7: Fast filter speed select
  - 0: Window length is 10 samples
  - 1: Window length is 4 samples
- Bit 5-4: Charge frequency divider
  - 00: 1/2
  - 01: 1/4
  - 10: 1/8
  - 11: 1/16
- Bit 3: Increment delay
  - 0: Pre-charge delay is at default
  - 1: Increase pre-charge delay to improve low light performance
- Bit 2: CS size
  - 0: Prox storage capacitor size is 15pF
  - 1: Prox storage capacitor size is 60pF

8.9.2 ALS settings 1

ALS settings 1 (0x71)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	ATI Target (x32)						Multiplier calibration	

Bit definitions:

- Bit 7-2: ATI Target for ALS ch4 = ATI Target x 32
- Bit 1-0: Multiplier calibration
  - 0-3: Fine multiplier factor calibration for ALS

8.9.3 IR settings 0

IR settings 0 (0x72)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Fast Filter	Internal use	CHARGE FREQ	Inc Delay	CSz	ACTV IR GAIN	ACTV IR GAIN	

Bit definitions:

- Bit 7: Fast filter speed select
  - 0: Window length is 5 samples
  - 1: Window length is 2 samples
- Bit 5-4: Charge frequency divider
  - 00: 1/2
  - 01: 1/4
  - 10: 1/8
  - 11: 1/16
- Bit 3: Increment delay
  - 0: Pre-charge delay is at default
  - 1: Increase pre-charge delay to improve low light performance
- Bit 2: CS size
  - 0: Prox storage capacitor size is 15 pF
  - 1: Prox storage capacitor size is 60 pF
- Bit 1-0: Active IR Gain base value
  - 0-3: Compensation = (ACTV IR GAIN + ALS Range Value)*2

8.9.4 IR settings 1

IR settings 1 (0x73)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	ATI Target (x32)						Multiplier calibration	

Bit definitions:

- Bit 7-2: ATI Target for ALS ch 4 = ATI Target x 32
- Bit 1-0: Multiplier calibration
  - 0-3: Fine multiplier factor calibration for IR

8.9.5 Multipliers Ch2

Multipliers Ch2 (0x74)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	-		MULTIPLIER COARSE		MULTIPLIER FINE			

Bit definitions:

- Bit 5-4: Multiplier coarse
  - 0-4: Coarse multiplier selection
- Bit 3-0: Multiplier fine
  - 0-15: Fine multiplier selection

8.9.6 Multipliers Ch3/4

Multipliers Ch3_Ch4 (0x75)								
Bit Number	7	6	5	4	3	2	1	0

Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	-		MULTIPLIER COARSE		MULTIPLIER FINE			

Bit definitions:

- Bit 5-4: Multiplier coarse
  - 0-4: Coarse multiplier selection
- Bit 3-0: Multiplier fine
  - 0-15: Fine multiplier selection

8.10 Active IR UI settings

8.10.1 Active IR UI settings

Active IR UI settings (0x90)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	-	R/W	R/W	-	-	R/W	R/W
Name	-	-	Hysteresis_T		-	-	Hysteresis_P	

Bit definitions:

- Bit 5-4: Touch Hysteresis
  - 00: Disabled
  - 01: 1/4 of threshold
  - 10: 1/8 of threshold
  - 11: 1/16 of threshold
- Bit 1-0: Proximity Hysteresis
  - 00: Disabled
  - 01: 1/4 of threshold
  - 10: 1/8 of threshold
  - 11: 1/16 of threshold

8.10.2 Active IR UI proximity threshold

Active IR UI proximity threshold (0x91)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Proximity threshold value							

Bit definitions:

- Bit 7-0: Proximity threshold = Proximity threshold value

8.10.3 Active IR UI touch threshold

Active IR UI touch threshold (0x92)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Touch threshold value							

Bit definitions:

- Bit 7-0: Touch threshold = Touch threshold value * 4

8.11 Hall-effect sensor settings

8.11.1 Hall-effect settings 0

Hall-effect settings 0 (0xA0)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	-	R/W	R/W	-	-	R/W	R/W
Name	-	-	CHARGE FREQ		reserved		AUTO_ATI_MODE	

Bit definitions:

- Bit 5-4: Charge frequency divider
  - 00: 1/2
  - 01: 1/4
  - 10: 1/8
  - 11: 1/16
- Bit 1-0: Auto ATI Mode
  - 00: ATI disabled
  - 01: Partial ATI (all multipliers are fixed)
  - 10: Semi-Partial ATI (only coarse multipliers are fixed)
  - 11: Full-ATI

8.11.2 Hall-effect setting 1

Hall-effect settings 1 (0xA1)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	ATI_BASE		ATI_TARGET (x32)					

Bit definitions:

- Bit 7-6: Auto ATI base value
  - 00: 75
  - 01: 100
  - 10: 150
  - 11: 200
- Bit 5-0: Auto ATI target
  - ATI target is 6-bit value x 32

8.11.3 Compensation Ch5/6

Compensation Ch5/6 (0xA2)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Compensation (0-7)							

Bit definitions:

- Bit 7-0: Compensation lower 8-bits
  - 0-255: Lower 8-bits of the compensation value.

8.11.4 Multipliers Ch5/6

Multipliers Ch5/6 (0xA3)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	COMPENSATION (8-9)		MULTIPLIERS COARSE		MULTIPLIERS FINE			

Bit definitions:

- Bit 7-6: Compensation (8-9)
  - 0-3: Upper 2-bits of the Compensation value.
- Bit 5-4: Multiplier coarse
  - 0-3: Coarse multiplier selection
- Bit 3-0: Multiplier fine
  - 0-15: Fine multiplier selection.

8.12 Hall-effect switch UI settings

8.12.1 Hall-effect switch UI settings

Hall-effect switch UI settings (0xB0)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	R/W	R/W	R/W	-	R/W	R/W	R/W
Name	-	Linear Mode	Hysteresis_T		-	Swap Direction	Hysteresis_P	

Bit definitions:

- Bit 6: Linearize Output
  - 0: Disabled
  - 1: Enabled
- Bit 5-4: Touch Hysteresis
  - 00: Disabled
  - 01: 1/4 of threshold
  - 10: 1/8 of threshold
  - 11: 1/16 of threshold
- Bit 2: Swap field direction indication
  - 0: Disabled
  - 1: Enabled
- Bit 1-0: Proximity Hysteresis
  - 00: Disabled
  - 01: 1/4 of threshold
  - 10: 1/8 of threshold
  - 11: 1/16 of threshold

8.12.2 Hall-effect switch UI proximity threshold

Hall-effect switch UI proximity threshold (0xB1)								
Bit	7	6	5	4	3	2	1	0

Number								
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Proximity threshold value							

Bit definitions:

- Bit 7-0: Proximity threshold = Proximity threshold value

8.12.3 Hall-effect switch UI touch threshold

Hall-effect switch UI touch threshold (0xB2)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Touch threshold value							

Bit definitions:

- Bit 7-0: Touch threshold = Touch threshold value * 4

8.13 Device and power mode settings

8.13.1 System settings

System settings (0xD0)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	W=1	W=1	R/W	R/W	R/W	R/W	W=1	W=1
Name	SOFT RESET	ACK RESET	EVENT MODE	8MHz	COMMS ATI	ATI BAND	REDO ATI	RESEED

Bit definitions:

- Bit 7: Software Reset (***Set only, will clear when done***)
  - 1: Causes the device to perform a WDT reset
- Bit 6: ACK Reset (***Set only, will clear when done***)
  - 1: Acknowledge that a reset has occurred. This event will trigger until acknowledged.
- Bit 5: Event mode enable
  - 0: Event mode disabled. Default streaming mode communication.
  - 1: Event mode communication enabled.
- Bit 4: Main Clock frequency selection
  - 0: Run FOSC at 16MHz
  - 1: Run FOSC at 8MHz
- Bit 3: Communications during ATI
  - 0: No communications are generated during ATI
  - 1: Communication continue as setup regardless of ATI state.
- Bit 2: Re-ATI Band selection
  - 0: Re-ATI when outside 1/8 of ATI target
  - 1: Re-ATI when outside 1/16 of ATI target
- Bit 1: Redo ATI on all channels (***Set only, will clear when done***)
  - 1: Redo the ATI on all channels
- Bit 0: Reseed all Long-term filters (***Set only, will clear when done***)
  - 1: Reseed all channels

8.13.2 Active channels

Active channels (0xD1)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	-	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

Bit definitions:

- Bit 6: Ch6 (***note: Ch5 and Ch6 must both be enabled for Hall-effect switch UI to be functional***)
  - 0: Channel is disabled
  - 1: Channel is enabled
- Bit 5: Ch5 (***note: Ch5 and Ch6 must both be enabled for Hall-effect switch UI to be functional***)

- 0: Channel is disabled
- 1: Channel is enabled

- Bit 4: Ch4 (***note: Ch3 and Ch4 must both be enabled for Active IR UI to be functional***)
  - 0: Channel is disabled
  - 1: Channel is enabled
- Bit 3: Ch3 (***note: Ch3 and Ch4 must both be enabled for Active IR UI to be functional***)
  - 0: Channel is disabled
  - 1: Channel is enabled
- Bit 2: Ch2
  - 0: Channel is disabled
  - 1: Channel is enabled
- Bit 1: Ch1
  - 0: Channel is disabled
  - 1: Channel is enabled
- Bit 0: Ch0
  - 0: Channel is disabled
  - 1: Channel is enabled

8.13.3 Power mode settings

Power mode settings 0 (0xD2)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	NP SEG ALL	EN ULP MODE	DSBL AUTO MODE	POWER MODE		NP SEG RATE		

Bit definitions:

- Bit 7: Normal power segment bounds check
  - 0: NP-segment check on PRX channels only
  - 1: NP-segment check on all channels
- Bit 6: Allow auto ultra-low power mode switching
  - 0: ULP is disabled during auto-mode switching
  - 1: ULP is enabled during auto-mode switching
- Bit 5: Disable auto mode switching
  - 0: Auto mode switching is enabled
  - 1: Auto mode switching is disabled
- Bit 4-3: Manually select power mode (***note: bit 5 must be set***)
  - 00: Normal power mode. The device runs at the normal power rate, all enabled channels and UIs will execute.
  - 01: Low power mode. The device runs at the low power rate, all enabled channels and UIs will execute.
  - 10: Ultra-low power mode. The device runs at the ultra-low power rate, Ch0 is run as wake-up channel. The other channels execute at the NP-segment rate.
  - 11: Halt mode. No conversions are performed; the device must be removed from this mode using an I2C command.

- Bit 2-0: Normal power segment update rate
  - 000: ½ ULP rate
  - 001: ¼ ULP rate
  - 010: 1/8 ULP rate
  - 011: 1/16 ULP rate
  - 100: 1/32 ULP rate
  - 101: 1/64 ULP rate
  - 110: 1/128 ULP rate
  - 111: 1/256 ULP rate

8.13.4 Normal power mode report rate

Normal power mode report rate (0xD3)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Normal power mode report rate in ms							

Bit definitions:

- Bit 7-0: Normal mode report rate in ms (***note: LPOSC timer has +- 4 ms accuracy***)

8.13.5 Low power mode report rate

Low power mode report rate (0xD4)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Low power mode report rate in ms							

Bit definitions:

- Bit 7-0: Low-power mode report rate in ms (***note: LPOSC timer has +- 4 ms accuracy***)

8.13.6 Ultra-low power mode report rate

Ultra-low power mode report rate (0xD5)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Ultra-low power mode report rate in 16 ms increments							

Bit definitions:

- Bit 7-0: Ultra-low power mode report rate in 16 ms increments

8.13.7 Auto mode timer

Auto mode timer (0xD6)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Name	Auto modes timer in 500 ms increments							

Bit definitions:

- Bit 7-0: Auto modes switching time in 500 ms increments

Global event mask (0xD7)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	-	R/W	R/W	R/W	R/W	R/W	R/W
Name	-	POWER MODE EVENT	SYS EVENT	IR EVENT	ALS EVENT	HALL EVENT	SAR EVENT	PROX SENSE EVENT

Bit definitions:

- Bit 6: Power mode event mask
  - 0: Event is allowed
  - 1: Event is masked
- Bit 5: System event mask
  - 0: Event is allowed
  - 1: Event is masked
- Bit 4: Active IR UI event mask
  - 0: Event is allowed
  - 1: Event is masked
- Bit 3: ALS UI event mask
  - 0: Event is allowed
  - 1: Event is masked
- Bit 2: Hall-effect UI event mask
  - 0: Event is allowed
  - 1: Event is masked
- Bit 1: SAR UI event mask
  - 0: Event is allowed
  - 1: Event is masked
- Bit 0: ProxSense UI event mask
  - 0: Event is allowed
  - 1: Event is masked

9 Electrical characteristics

9.1 Absolute Maximum Specifications

The following absolute maximum parameters are specified for the device:

Exceeding these maximum specifications may cause damage to the device.

Parameter	Absolute maximum
Operating temperature	-40°C to 85°C
Supply Voltage (VDDHI – GND)	3.6V
Maximum pin voltage	VDDHI + 0.5V (may not exceed VDDHI max)
Maximum continuous current (for specific pins)	10mA
Minimum pin voltage	GND - 0.5V
Minimum power-on slope	100V/s
ESD protection	±8kV (Human body model)

9.2 Power On-reset/Brown out

DESCRIPTION	Conditions	PARAMETER	MIN	MAX	UNIT
Power On Reset	V_{DDHI} Slope ≥ 100V/s @25°C	POR	TBC	TBC	V
Brown Out Detect	V_{DDHI} Slope ≥ 100V/s @25°C	BOD	TBC	TBC	V

9.3 Digital input/output trigger levels

DESCRIPTION	Conditions	PARAMETER	MIN	TYPICAL	MAX	UNIT
All digital inputs	VDD = 1.8V	Input low level voltage	TBC	TBC	TBC	V
All digital inputs	VDD = 1.8V	Input high level voltage	TBC	TBC	TBC	V
All digital inputs	VDD = 3.3V	Input low level voltage	TBC	TBC	TBC	V
All digital inputs	VDD = 3.3V	Input high level voltage	TBC	TBC	TBC	V

9.4 Infrared LED Characteristics [i]

Parameter	MIN	TYPICAL	MAX	UNIT
Forward Voltage (V_f)	-	-	1.6	V
Reverse Voltage (V_r)	-	-	5	V
Continues Forward Current (I_f)	-	-	80	mA
Radiated Power (I_f = 20 mA)	4.5	-	-	mW
Peak Wavelength (λ_p)	830	-	870	nm

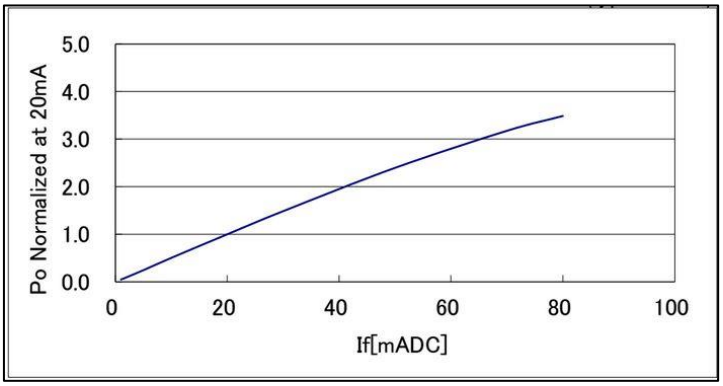


Figure 9.1 Forward LED Current vs. Normalized Radiated Power.

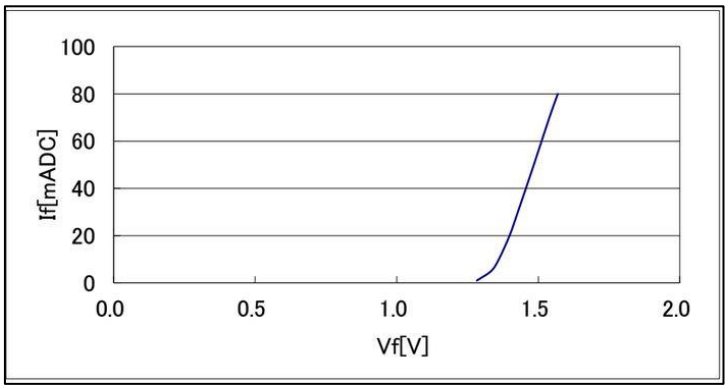


Figure 9.2 Forward LED Voltage vs. Forward LED Current.

9.5 Current consumptions

9.5.1 Capacitive sensing alone

Power mode	Conditions	Report rate	MIN	TYPICAL	MAX	UNIT
NP mode	VDD = 1.8V		TBC	TBC	TBC	mA
NP mode	VDD = 3.3V		TBC	TBC	TBC	mA
LP mode	VDD = 1.8V		TBC	TBC	TBC	mA
LP mode	VDD = 3.3V		TBC	TBC	TBC	mA
ULP mode	VDD = 1.8V		TBC	TBC	TBC	mA
ULP mode	VDD = 3.3V		TBC	TBC	TBC	mA

[i] Details in this section are provided by DOWA ELECTRONICS MATERIALS CO.,LTD

Power mode	Conditions	Report rate	MIN	TYPICAL	MAX	UNIT
Halt mode	VDD = 1.8V		TBC	TBC	TBC	mA
Halt mode	VDD = 3.3V		TBC	TBC	TBC	mA

9.5.2 ALS sensing alone

Power mode	Conditions	Report rate	MIN	TYPICAL	MAX	UNIT
NP mode	VDD = 1.8V		TBC	TBC	TBC	mA
NP mode	VDD = 3.3V		TBC	TBC	TBC	mA
LP mode	VDD = 1.8V		TBC	TBC	TBC	mA
LP mode	VDD = 3.3V		TBC	TBC	TBC	mA
ULP mode	VDD = 1.8V		TBC	TBC	TBC	mA
ULP mode	VDD = 3.3V		TBC	TBC	TBC	mA
Halt mode	VDD = 1.8V		TBC	TBC	TBC	mA
Halt mode	VDD = 3.3V		TBC	TBC	TBC	mA

9.5.3 Active IR sensing alone excluding LED current

Power mode	Conditions	Report rate	MIN	TYPICAL	MAX	UNIT
NP mode	VDD = 1.8V		TBC	TBC	TBC	mA
NP mode	VDD = 3.3V	100 Hz	TBC	40	TBC	uA
NP mode	VDD = 1.8V		TBC	TBC	TBC	mA
NP mode	VDD = 3.3V	50 Hz	TBC	27	TBC	uA
LP mode	VDD = 1.8V		TBC	TBC	TBC	mA
LP mode	VDD = 3.3V	10 Hz	TBC	7.5	TBC	uA
ULP mode	VDD = 1.8V		TBC	TBC	TBC	mA
ULP mode	VDD = 3.3V		TBC	TBC	TBC	mA
Halt mode	VDD = 1.8V		TBC	TBC	TBC	mA
Halt mode	VDD = 3.3V		TBC	TBC	TBC	mA

9.5.4 Active IR sensing LED Current @ 250 Lux

Resistor	Conditions	Report rate	Duty Cycle	PEAK	AVG	UNIT
5.6 Ω	VDD = 1.8V	50 Hz	0.3%	54	0.16	mA
33 Ω	VDD = 3.3V	50 Hz	0.3%	55	0.16	mA
8.2 Ω	VDD = 1.8V	50 Hz	0.3%	37	0.11	mA
47 Ω	VDD = 3.3V	50 Hz	0.3%	38	0.11	mA
10 Ω	VDD = 1.8V	50 Hz	0.3%	30	0.09	mA
56 Ω	VDD = 3.3V	50 Hz	0.3%	32	0.1	mA

9.5.5 Hall-effect sensing alone

Power mode	Conditions	Report rate	MIN	TYPICAL	MAX	UNIT
NP mode	VDD = 1.8V		TBC	TBC	TBC	mA
NP mode	VDD = 3.3V	100 Hz	TBC	0.18	TBC	mA
NP mode	VDD = 1.8V		TBC	TBC	TBC	mA
NP mode	VDD = 3.3V	50 Hz	TBC	0.15	TBC	mA
LP mode	VDD = 1.8V		TBC	TBC	TBC	mA
LP mode	VDD = 3.3V	10 Hz	TBC	60	TBC	uA
ULP mode	VDD = 1.8V		TBC	TBC	TBC	mA
ULP mode	VDD = 3.3V		TBC	TBC	TBC	mA
Halt mode	VDD = 1.8V		TBC	TBC	TBC	mA
Halt mode	VDD = 3.3V		TBC	TBC	TBC	mA

9.6 Capacitive loading limits

To be completed.

9.7 Active IR measurement limits

To be completed.

9.8 Hall-effect measurement limits

To be completed.

10 Package information

10.1 DMA 3.94 x 2.36 x 1.37 – 9-pin package and footprint specifications

Table 10.1 DMA 3.94 x 2.36 x 1.37 – 9-pin package dimensions (bottom)

Dimension	Min. [mm]	Nom. [mm]	Max. [mm]
A	3.84	3.94	4.04
B	2.26	2.36	2.46

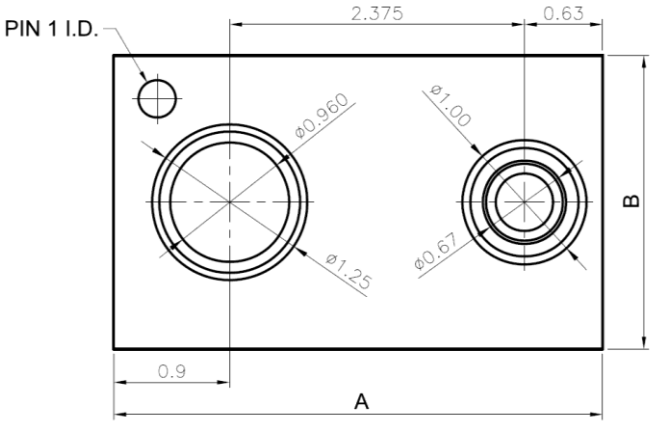


Figure 10.1 DMA 3.94 x 2.36 x 1.37 – 9-pin package dimensions (top view).

Table 10.2 DMA 3.94 x 2.36 x 137 – 9-pin package dimensions (side)

Dimension	Min. [mm]	Nom. [mm]	Max. [mm]
C	1.27	1.37	1.47
D	-	1.07	-
E	-	0.30	-

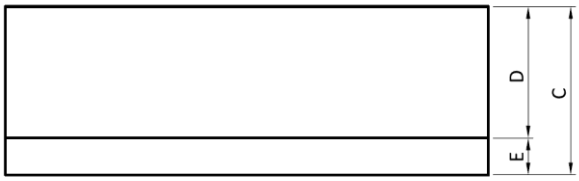


Figure 10.2 DMA 3.94 x 2.36 x 1.37 – 9-pin package dimensions (side view)

Table 10.3 DMA 3.94 x 2.36 x 1.37 – 9-pin landing pad dimensions

Dimension	Min. [mm]	Nom. [mm]	Max. [mm]
F	0.65	0.70	0.75
G	-	0.97	-
H	0.65	0.70	0.75
I	-	0.41	-
J	0.65	0.70	0.75
K	0.72	0.82	0.92
L	0.65	0.70	0.75
M	-	0.12	-

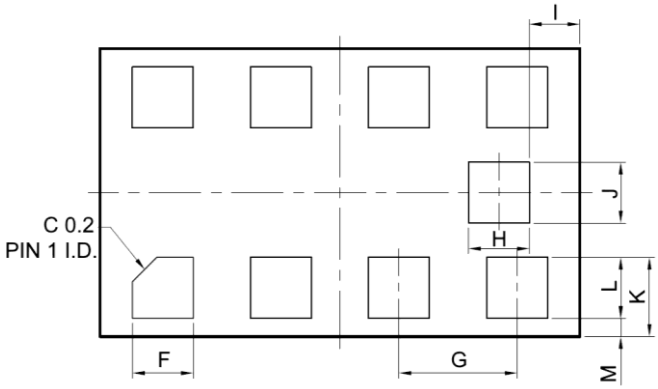
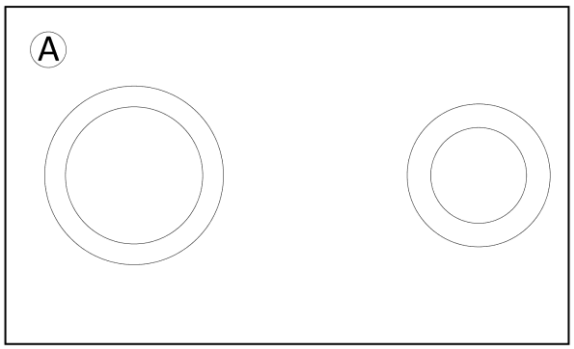


Figure 10.3 DMA 3.94 x 2.36 x 1.37 – 9-pin landing pad dimensions (bottom view)

10.2 Device marking



PIN 1 MARKING	**A**	=	Dot to indicate pin 1

10.3 Ordering information

To be completed once in production.

10.4 Tape and reel specification

To be completed once in production.

10.5 MSL Level

Moisture Sensitivity Level (MSL) relates to the packaging and handling precautions for some semiconductors. The MSL is an electronic standard for the time period in which a moisture sensitive device can be exposed to ambient room conditions (approximately 30°C/85%RH see J-STD033C for more info) before reflow occur.

Package	Level (duration)
DMA 3.94 x 2.36 x 1.37 – 9-pin	MSL 2 (Unlimited at ≤30°C / 85% RH) Reflow profile peak temperature < 260°C for < 30 seconds

11 Datasheet revisions

11.1 Revision history

Revision 1.0 – First release version

11.2 Errata

Appendix A. 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
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