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IQS680 Datasheet

Combination sensor with dual channel capacitive proximity/touch, Pyroelectric Infrared Radial sensor and metal detection capabilities

The IQS680 ProxFusion® IC is a multifunctional Capacitance, Pyroelectric Infrared Radial (PIR) & Inductance sensor designed for applications such as domestic energy efficient lighting applications with movement detection. The IQS680 is an ultra-low power solution designed for short or long term activations through any of the sensing channels. The IQS680 operates standalone or via the I²C protocol and custom configurations are stored in an on-chip EEPROM.

Features

- **Unique combination of Sensors:**
  - Capacitive Sensing
  - Inductive Sensing
  - PIR Sensing
- **Capacitive Sensing**
  - 2pF to 200pF external capacitive load capability
  - Fully adjustable sensing options
  - Mutual- or self-capacitance.
- **Inductive Sensing**
  - Distinguish between ferrous and non-ferrous metals
  - Only external sense coil required (PCB trace)
- **PIR Sensing:**
  - DSP algorithm for long range movement detection.
  - Automatic drift compensation.
- **Multiple integrated UI's**
- **Automatic Tuning Implementation** (ATI) – performance enhancement (10bit ATI)
- **EEPROM** included on-chip for calibration data and settings.
- Minimal external components
- Standard **I²C** interface (polling with sub 1ms clock stretching)
- Optional RDY indication for standalone mode operation
- **Low Power Consumption:**
  - 300uA
  - (100 Hz response)
  - 10uA
  - (10 Hz response)
- **Supply Voltage:** 1.75V to 3.6V

DFN 3 x 3 x 0.7

10-Pin

Representations only, not actual markings

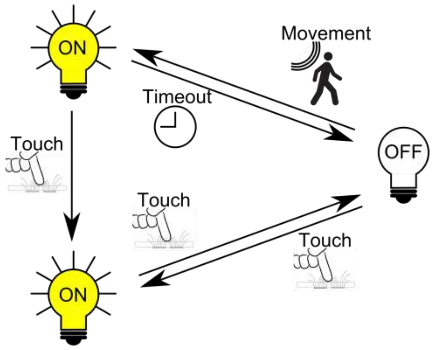


Figure 1: Under cabinet UI (PIR and Prox)

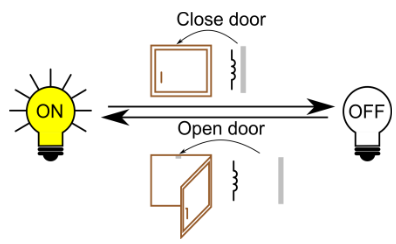


Figure 2: In cabinet UI (Inductive sensor)

Applications

- Under Cabinet Lighting (UCL)
- Standard PIR sensor cost reduction
- Smart Lights
- Night Lights
- Battery powered PIR sensors solutions
- Movement detection

Available Packages	
T_A	DFN10
-20°C to 85°C	IQS680

Table of Contents

List of Abbreviations

ATI	Automatic Tuning Implementation
BOD	Brown Out Detection
FOV	Field Of View
GND	Ground
I^2C	Inter-Integrated Circuit
ICI	Internal Capacitor Implementation
LTA	Long Term Average
MSL	Moisture Sensitivity Level
OTP	One-Time Programmable
PIR	Pyroelectric Infrared Radial
POR	Power On Reset
PWM	Pulse Width Modulation
THR	Threshold
TO	Time-Out
UI	User Interface

List of symbols

C_{ATI}	ATI Compensation
CS_{PIR}	PIR sensor Counts
CS_{SS}	Steady-State CS_{PIR}
CS_T	Touch Counts
C_S	Internal Reference Capacitor
C_X	Sense electrode
D_{THR}	PIR Counts Deviation Threshold
f_S	Sampling frequency
M_{ATI}	ATI Multiplier
P_{THR}	Proximity event Threshold
R_X	Receiving electrode
T_{THR}	Touch event Threshold
T_X	Transmission electrode
V_{DD}	Supply voltage
V_{SS}	Ground

1 Introduction

1.1 ProxFusion®

The ProxFusion® sensor series provide all 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

The IQS680 is available in the DFN10 packaging. The pin-outs and functionality are given below.

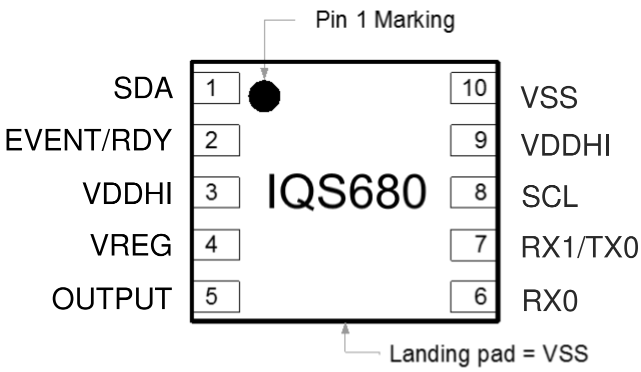


Figure 1.1: IQS680 pin-out (DFN10 package; device markings may differ)

Table 1-1: Pin-out descriptions

Pin	Name	Type	Function
1	SDA	I²C	**SDA** (I²C Data signal)
2	EVENT	Digital Out	Active output on movement and when PIR is blocked
2	RDY	I²C	**RDY** (I²C Ready interrupt signal)
3	VDDHI	Supply Input	Supply: 1.75V – 3.6V
4	VREG	Regulator output	Requires external capacitors
5	OUTPUT	Digital Out	Active high/low open-drain/push-pull output with PWM
6	Rx0	Analogue	Charge Receive electrode for sensors
7	Rx1	Analogue	Charge Receive electrode for sensors
7	Tx0	Analogue	Charge Transfer electrode for sensors
8	SCL	I²C	**SCL** (I²C Clock signal)
9	VDDHI	Supply Input	Supply: 1.75V – 3.6V
10	VSS	Voltage reference	Ground connection

1.3 Reference schematic

The PIR can be powered from either VREG or VDD. For long range (> 1m) applications, it is suggested to power the PIR from VDD. For shorter range and lower power applications it is suggested to power the PIR from VREG. An RC filter is placed at the PIR output if required. The PIR sensors need to be placed as close as possible to the IQS680 to ensure RF immunity. By-pass capacitors can be used on the output signal of the PIR as well as the power supply rails to remove unwanted noise. As seen in Figure 1-2, noise suppression components can be added if a problem is experienced with noise. These components can be changed based on the noise requirements of the application. Resistor **R5** and needs to be added if the PIR sensor can not be placed close to the IC. Resistors **R6, R7, R11** and **R13** is calculated based on the bias current requirement of the PIR element. If using the Inductive UI **R4** and **R5** should be replaced with a ferrite bead to increase RF immunity.

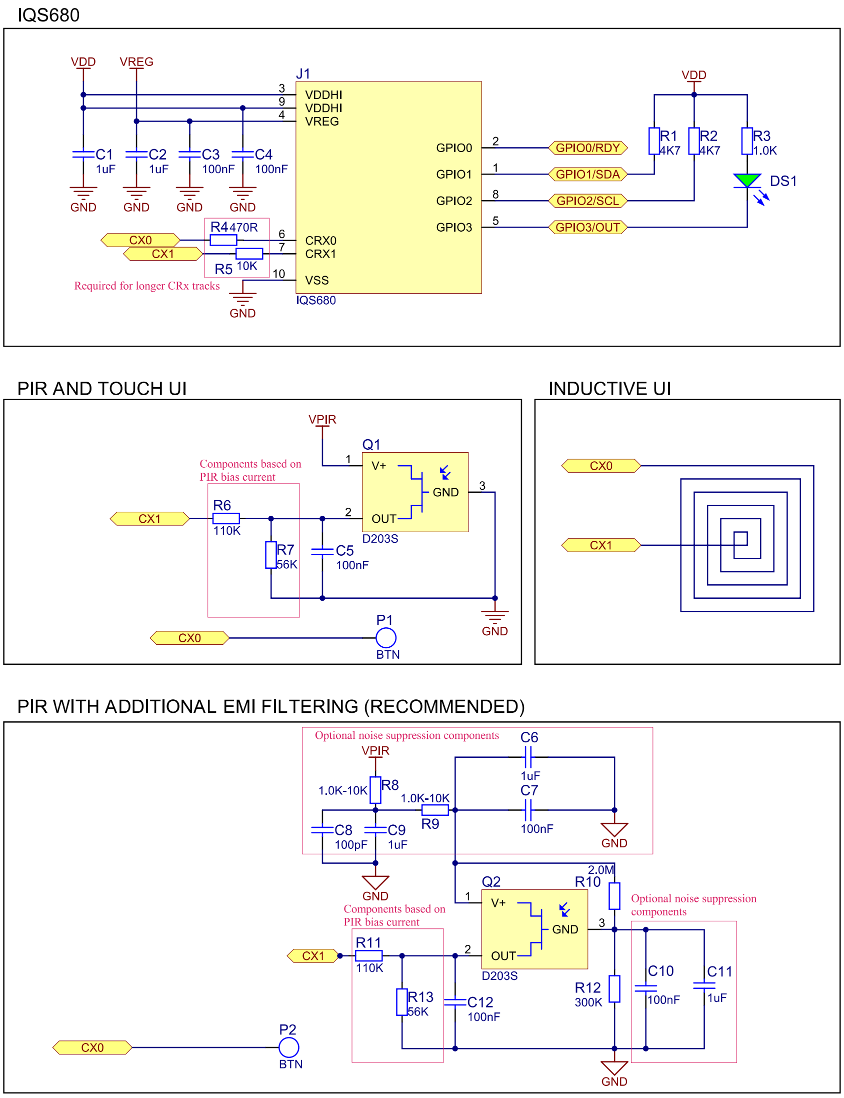


Figure 1.2 IQS680 reference schematic

1.4 Sensor channel combinations

The table below summarizes the IQS680's sensor and channel associations.

Table 1-2 Sensor - channel allocation

	Sensor / UI type	CH0	CH1	CH2
Capacitive	Movement detection	○ Touch	• PIR	
Inductive	Metal detection	○ Touch rejection		• Inductive

Key:

- • - Optional implementation
- ○ - Fixed use for UI

1.5 Features

The IQS680 is a capacitive sensing controller designed for both integrated and standalone Pyroelectric Infrared Radial (PIR) sensing applications. The device offers highly dynamic and adjustable PIR sensing range, depending on the lens chosen (0 – 10m), as well as a high sensitivity proximity (Prox) and contact (Touch) detection through a dedicated sensor line (C_X).

The device includes advanced Digital Signal Processing (DSP) capabilities for on-chip PIR signal analysis. This, combined with the Automatic Tuning Implementation (ATI) algorithm which calibrates the device to the sense electrode, yields a highly stable, high sensitivity movement detection controller. Further features of the device include an internal voltage regulator and Internal Capacitor Implementation (ICI) to reduce external components. The analogue circuitry is also capable of Power On Reset (POR) detection as well as Brown Out Detection (BOD).

Furthermore, the device has an inductive sensing mode that allows for the detection of non-ferret metals near the sensor.

The device can also be configured by means of an on-chip EEPROM, such as choosing the device output format, event durations, sensitivity and storing calibration data. The output options include an open-drain or push-pull, active high or low output with Pulse Width Modulation (PWM) as well as the standard I^2C interface.

1.6 Operation

The device has been designed to be used in standalone battery operated automated lighting applications with on/off touch control capabilities. Furthermore, standard I^2C interface allows the device to be used in an integrated environment.

The capacitive sensing line of the device can reliably observe the measured results at various levels, which enables it to distinguish between a Prox or Touch event. This allows for a variety of User Interface (UI) responses. The ATI algorithm allows for the adaptation to a wide range of sensing pad sizes.

2 User Interface

Although standard I^2C interface is available, the IQS680 is designed as a standalone device with a single logic output. There are three User Interfaces (UI's) on the device, namely Movement detection, Touch detection and Metal detection. The first UI uses a PIR sensor to detect movement over a distance and the second senses touch by means of a capacitive sensing electrode (C_X). The latter operates with a single copper coil to detect non-ferrite metals in close proximity.

Flow-diagrams of the three UI's are given in Figure 2.1 below. Note that when the output is in PWM mode, it is not considered to be in an active state. More detail is provided on this in the subsections that follow.

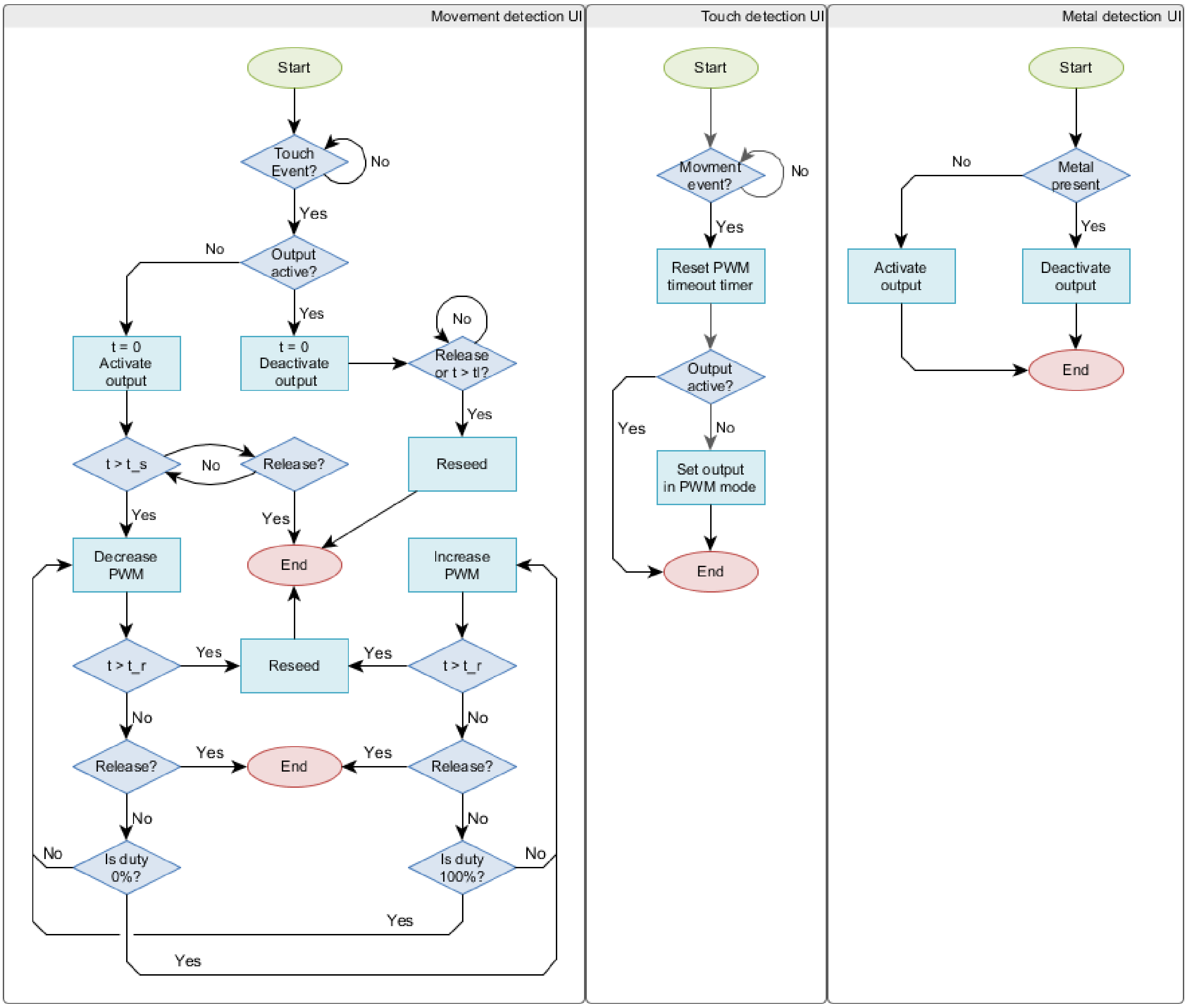


Figure 2.1: UI flow-diagrams

2.1 Movement detection UI

2.1.1 PIR sensor

The PIR sensor functions as the movement over a distance interface. Typical PIR sensors have a sensing range of up to 10m, with a radial FOV of 120°. Care should be taken when designing the housing of the PIR sensor as well as the choice of lens, as this plays a pivotal role in sensitivity, range and FOV of the PIR sensor.
Given that the output is in an inactivate state, the IQS680 will switch the output into PWM mode if any movement is detected within the PIR's FOV. The output will exit PWM mode after a predefined time period, upon which the output will return to an idle state.
However, if movement is detected whilst the output is already in PWM mode, the deactivation timers will be reset. This implies that the device will only return to an idle state once no movement was detected of the given time period. As long as the output is active, any movement detection will be ignored.

2.1.2 Touch button

There are 2 trigger levels to which the capacitive electrode will respond.
The first of these is a Prox event. This event should trigger once the user comes within a small distance to the C_X (in the order of 5cm). This trigger level will not result in an active output, but instead the device will enter Zoom mode. In this mode, the device will sample C_X at 60Hz rather than the selected frequency (f_S) chosen by the designer. This mode switching feature increases the responsiveness of the touch functionality of the device whilst maintaining low power consumption during idle operation.
The second trigger level is a Touch event. This is triggered when the user physically touches the device surface directly above the C_X pad.
In the case that the output is inactive during the touch event, the output will be activated. If the touch remains for longer than 500ms the output will start to dim. If a PWM duty of 0% is reached, the duty will start to increase. This process will continue until the touch is released.
If the output is active when a touch event is registered, the output will be deactivated.

2.2 Metal detection UI

2.2.1 Inductive coil

With a coil connected between the C_{X0} and C_{X1} pins, the IQS680 passes a current though the coil and detects any deviations in the current. The IQS680 interpret these fluctuations in current as the presence or absence of metals, such as copper, in the E-field generated by the current passed through the coil.
If the IQS680 detect metal in close proximity to the coil, the output is deactivated and inversely, if no metal is detected the output is activated.
A second optional capacity measurement is also done on the coil to detect and compensate for any capacitive effect that may be exerted on the coil. This allows the IQS680 to refrain from responding to any touches made on the coil.

2.3 Event output responses

The following figure depicts the responses of the device for all the possible user inputs, given all the possible states of the output.

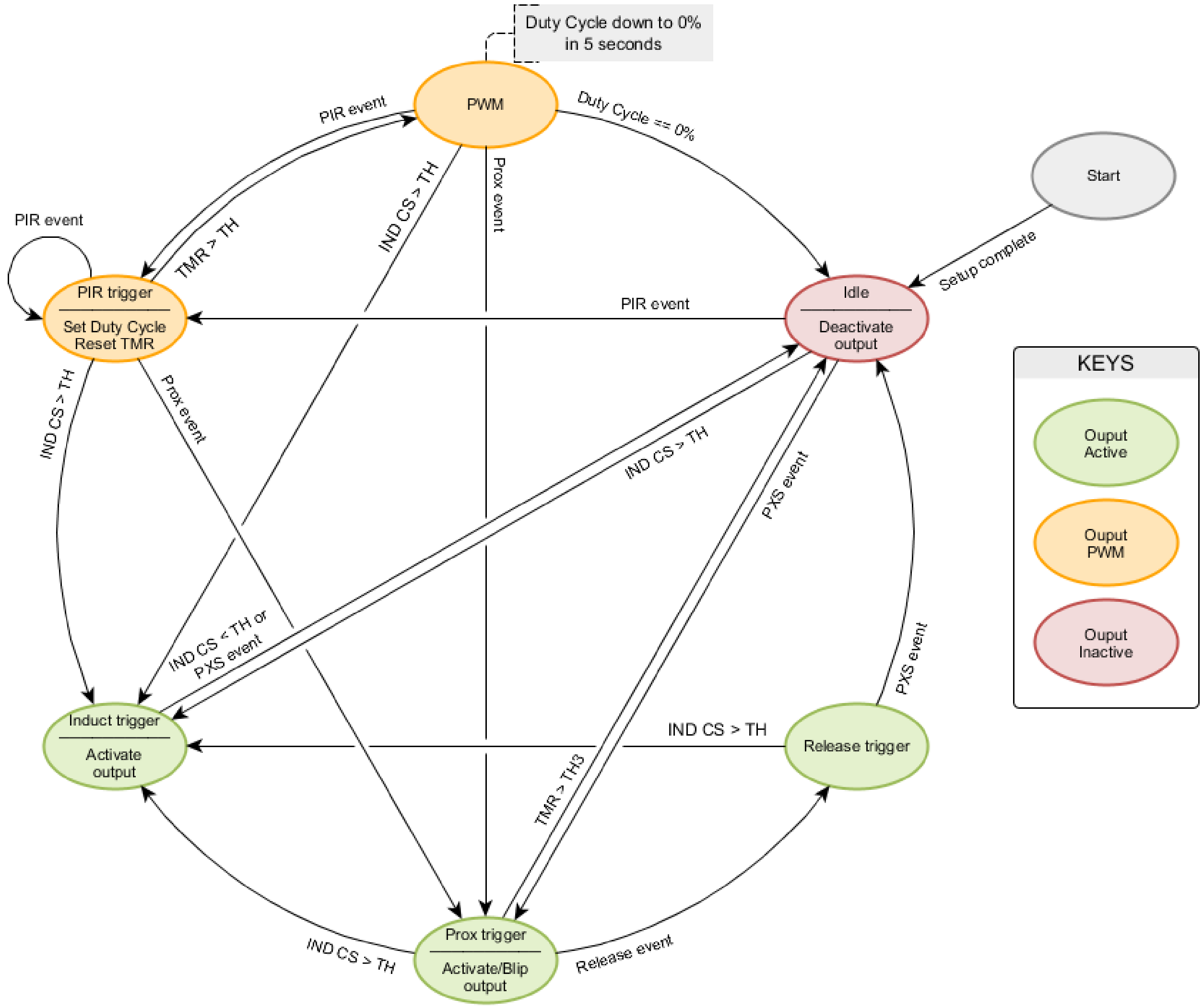


Figure 2.2: State diagram of the IQS680 output

3 Inductive sensing

3.1 Channel specifications

The IQS680 requires 2 sensing lines for inductive sensing. Channel 2 is dedicated to the inductive UI.

Table 3-1 Inductive sensor – channel allocation

Mode	CH0	CH1	CH2
Inductive	○Touch rejection		• Inductive

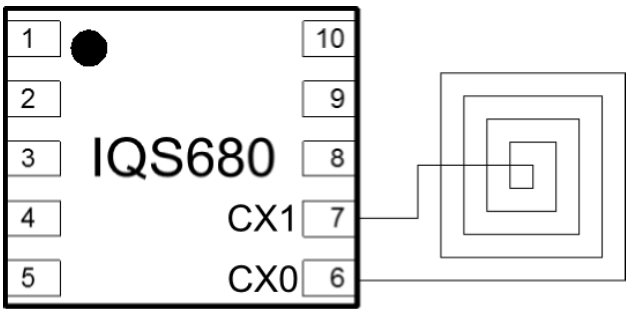
Key:

- • - Optional implementation
- ○ - Fixed use for UI

3.2 Hardware configuration

A ferrite bead can be placed in serie with the coil to increase RF immunity.

Table 3-2 Inductive coil hardware description

	Inductive coil
Metal detect UI	

3.3 Register configuration

3.3.1 Registers to configure for inductive sensing:

Inductive sensing settings registers.

Address	Name	Description	Recommended setting
0x50	Ch0 ProxFusion Settings 0	Sensor mode and configuration.	Sensor mode should be set to Capacitive mode. RX 0 and RX 1 should be enabled and no Tx.
0x52	Ch2 ProxFusion Settings 0	Sensor mode and configuration of each channel.	Sensor mode should be set to Inductive mode. Enable TX1 and RX0
0x53	ProxFusion Settings 1	Global settings for the ProxSense sensors	None
0x54, 0x56	Ch0/Ch2 ProxFusion Settings 2	ATI settings for ProxFusion sensors	ATI target should be more than ATI base to achieve an ATI
0x57	ProxFusion Settings 3	Additional Global settings for ProxFusion sensors	Touch detection enabled
0x60	Proximity Threshold	Proximity Threshold for UI	Less than touch threshold
0x61	Touch Threshold	Touch Threshold for UI	None
0x90	Inductive Prox Threshold	Proximity Threshold for Inductive UI	Less than Enter/Exit Threshold
0x97	Metal Enter NM Threshold	Enter Threshold in non-metal state for Inductive UI	None
0x98	Metal Enter M Threshold	Enter Threshold in metal state for Inductive UI	None
0x99	Metal Exit NM Threshold	Exit Threshold in non-metal state for Inductive UI	None
0x9A	Metal Exit M Threshold	Exit Threshold in metal state for Inductive UI	None

3.4 Sensor data output and flags

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

a) Event Flags (0x10) to prompt for inductive sensor activity. Bit 4 denoted as **IND ENTER** will indicate when a metal object enters the induction sensing area. Bit 5 denoted as **IND EXIT** will indicate when a metal object exits the induction sensing area.

Event Flags (0x10)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	Read							
Name	SHOW RESET	-	**IND EXIT**	**IND ENTER**	-	-	PIR TRIGGER	TOUCH

b) Global UI Flags (0x12) to prompt for inductive sensor activation. Bit3 denoted as **METAL PRESENT** will indicate the detection of a metal object using the inductive sensing. Bit 6/7 provides the classic prox/touch two level activation outputs.

Global UI Flags (0x12)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	Read							
Name	**METAL PRESENT**	**TOUCH CH2**	**PROX CH2**	PIR TRIGGER	PIR EVENT	STABLE CH0	TOUCH CH0	PROX CH0

c) Channel Counts Ch2 (0x24 - 0x25) registers will provide a combined 16-bit value to acquire the magnitude of the inductive sensed object.

Channel counts Ch2 (0x24/0x25)																
Bit Number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Data Access	Read															
Name	Count High Byte								Count Low Byte							

d) Metal Detect Base (0x34 - 0x35) registers will provide a combined 16-bit value of the metal detect base value.

Metal Detect Base (0x34/0x35)																
Bit Number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Data Access	Read															
Name	Metal Detect Base High Byte								Metal Detect Base Low Byte							

Bit definitions:

- Bit 15-0: Base value for metal detection

e) Channel 2 LTA (0x36-0x37) registers will provide a combined 16-bit value of the LTA of channel 2.

Channel 2 LTA (0x36/0x37)																
Bit Number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Data Access	Read															
Name	LTA High Byte								LTA Low Byte							

Bit definitions:

- Bit 15-0: LTA filter value

4 Pyroelectric Infrared Radial (PIR) sensing

4.1 Channel Specifications

The IQS680 requires one sensing line for PIR sensing and one sensing line for touch sensing. Channel 1 is dedicated to the PIR UI.

Table 4-1 PIR sensor – channel allocation

Mode	CH0	CH1	CH2
Movement detection	○Touch	• PIR	

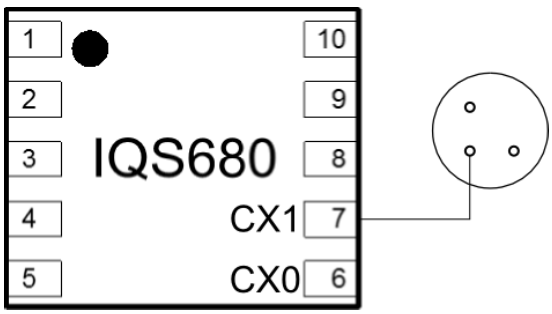
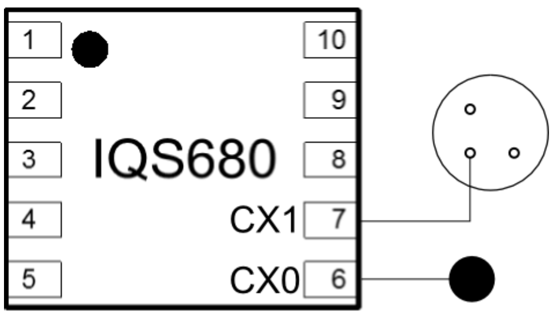
Key:

- ○ - Optional implementation
- • - Fixed use for UI

4.2 Hardware Configuration

In the table below are multiple options of configuring sensing (CX) electrodes to realize different implementations.

Table 4-2 PIR hardware description

	Self-capacitive configuration
PIR only	
PIR and touch button	

4.3 Register configuration

4.3.1 Registers to configure for the PIR and capacitive sensing:

PIR and capacitive sensing settings registers

Address	Name	Description	Recommended setting
0x50	Ch0 ProxFusion Settings 0	Sensor mode and configuration.	Sensor mode should be set to capacitive mode. RX 0 should be enabled and no Tx.
0x51	Ch1 ProxFusion Settings 0	Sensor mode and configuration.	Sensor mode should be set to PIR mode. RX 1 should be enabled and no TX.
0x53	ProxFusion Settings 1	Global settings for the ProxSense sensors	None
0x54, 0x55	Ch0/Ch1 ProxFusion Settings 2	ATI settings for ProxFusion sensors	ATI target should be more than ATI base to achieve an ATI
0x57	ProxFusion Settings 3	Additional Global settings for ProxFusion sensors	None
0x60	Proximity threshold	Proximity Threshold for UI	Less than touch threshold
0x61	Touch threshold	Touch Threshold for UI	None
0x90	PIR Settings	PIR Global Settings	Ignore polarity of events
0x91,0x92	PIR Threshold	PIR Event Threshold for UI	PIR Exit Event Threshold ≤ PIR Enter Event Threshold
0x93	PIR Threshold Scale Factor	PIR Threshold Scale Factor for UI	None

4.4 Sensor data output and flags

The following registers can be monitored by the master to detect PIR/touch sensor related events.

a) Event Flags (0x10) to prompt for PIR or touch sensor activity. Bit 1 denoted as **PIR TRIGGER** will indicate when the PIR is triggered by movement. Bit 0 denoted as **TOUCH** will indicate when the touch sensor is activated.

Event Flags (0x10)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	Read							
Name	SHOW RESET	-	IND EXIT	IND ENTER			**PIR TRIGGER**	**TOUCH**

b) Global UI Flags (0x12) to prompt for PIR or touch sensor activation. Bit3 denoted as **PIR EVENT** will indicate that a PIR event has occurred. Bit 0/1 provides the classic prox/touch two level activation outputs.

Global UI Flags (0x12)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	Read							
Name	METAL PRESENT	TOUCH CH2	PROX CH2	PIR TRIGGER	**PIR EVENT**	STABLE CH0	**TOUCH CH0**	**PROX CH0**

c) Lighting Flags (0x13) to prompt for lighting activity. Bit 4 is set when the PWM output is changing and is cleared when the PWM output is constant. Bit 3 is set when the duty cycle of the PWM output is increasing and is cleared when the duty cycle of the PWM output is decreasing.

Lighting Flags (0x13)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	Read							
Name	PIR STABLE	PIR RDY	BLIP BUSY	FADING	FADING IN		PIR/IND ACTIVATED	TOUCH ACTIVATED

d) Channel Counts (Raw) Ch1 (0x22 - 0x23) registers will provide a combined 16-bit value of the raw value.

Channel counts Ch1 (0x22-0x23)																
Bit Number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Data Access	Read															
Name	Count High Byte								Count Low Byte							

e) Channel Counts (filtered) Ch1 (0x34 - 0x37) registers will provide a combined 16-bit value of several filtered values. Channel 1 PDS provides the positive delta sum value. The delta is the difference between the previous sample counts and the current sample counts. Therefore, this value increase if the difference between the previous sample and current sample is positive (counts increasing).

Channel 1 PDS (0x34/0x35)																
Bit Number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Data Access	Read															
Name	PDS High Byte								PDS Low Byte							

- Bit 15-0: Positive Delta Sum Value

Channel 1 NDS provides the negative delta sum value. The delta is the difference between the previous sample counts and the current sample counts. Therefore, this value increase if the difference between the previous sample and current sample is negative (counts decreasing).

Channel 1 NDS (0x36/0x37)																
Bit Number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Data Access	Read															
Name	NDS High Byte								NDS Low Byte							

- Bit 15-0: Negative Delta Sim value

5 User Configurable Settings (UCS)

This section describes the user configurable options of the IQS680 in detail. User options are selected though the Azoteq GUI, which is used to write it in the device's EEPROM.

5.1 Sampling frequency

The frequency at which the device samples the sensors directly relates to its power consumption, where a higher sample rate requires a more power. The designer may select 1 of 4 possible sample frequencies as shown in Table 5-1. The sampling frequency can be set in the Sample Period (0xD5) register and Active Sample Period Adjustment (0xD4) registers.

Table 5-1 Sample frequency options

FREQ: Device sampling frequency select	
10 Hz	50 Hz
20 Hz	100 Hz

For a sampling frequency of 10 Hz and 20 Hz a PIR Filter Beta Value of 2 is recommended and for a sampling frequency of 50 Hz and 100 Hz a PIR Filter Beta Value of 3 is recommended.

5.2 Input options

The IQS680 includes 3 input modes, which define the sensors attached to the device. The mode can be selected in the ProxFusion Settings 0 (0x50-0x53; bits 7-4) registers. These options are given in the Table 5-2

Table 5-2 User Input options

INPUT: Input type select
PIR sensor only
PIR and capacitive sensors
Coil (metal detect) sensor

5.3 Output format options

The IQS680 includes 4 output formats. These options, given in Table 5-3, allow the designer to operate the load in the best configuration for the given application. The output format can be set in the System Settings 0 (0xD2; bits 7&2) register.

Table 5-3: Output formats

$OUTPUT_F$: Output format select
Active High & Push-pull
Active Low & Push-pull
Active High & Open-drain
Active Low & Open-drain

5.4 Lighting Modes

The IQS680 includes 3 output modes. These options, given in Table 5-4, allow the designer to operate the load in the best configuration for the given application.

Table 5-4: Output modes

$OUTPUT_T$: Output mode select
On/Off
Varied PWM
Fixed PWM
Pulse

In the "On/Off" output mode, the IQS680 will always activate the output on any event with a 100% PWM duty. In the "Varied PWM" mode, the IQS680 will cycle through a 0 – 100% PWM duty when a prolonged touch event is detected (longer than 1s), given that the touch event has activated the load. The "Pulse" mode will only generate a short pulse (10us - 250us, selectable in the Light Time Out (0xD8) register) for any event. The output mode can be set in the System Settings 1 (0xD3; bits 1-0) register.

5.5 Auto-off

By default the device's output will remain in an active state perpetually, given that the output is in a load driven mode. However, if the auto-off feature is selected, the output will be deactivated after a period of 1 hour. The Auto-off bit can be set in the System Settings 0 (0xD2; bit 4) register.

5.6 Proximity threshold

The Proximity Threshold (P_{THR}) defines the minimum required diverges of the Touch CS (CS_T) below the Long Term Average (LTA) for more than 4 consecutive cycles to trigger a proximity event. The IQS680 proximity threshold options range is 0 - 255, where typical values are approximately 8, enabling the designer to obtain the desired sensitivity and noise immunity for the touch electrode. The Proximity Threshold (P_{THR}) can be set in P Threshold (0x60) register.

5.7 Touch threshold

Similar to the proximity threshold, the Touch Threshold (T_{THR}) defines the minimum required diverges of the CS_T below the LTA for more than 2 consecutive cycles to trigger a touch event. The following equation illustrates how it is determined whether a touch event has occurred:

$$LTA \times \frac{CS_T}{256} > T_{THR}.$$

The IQS680 touch threshold options range is 0 - 255. The touch threshold is selected by the designer to obtain the desired touch sensitivity. The Touch Threshold (T_{THR}) can be set in the Threshold (0x61) register.

5.8 PIR event thresholds

Unlike the touch events, which are based on the absolute CS_T measurement, PIR events are based on the differential measurement of the PIR sensor CS (CS_{PIR}). Thus, a PIR Event Threshold (E_{THR}) defines the minimum required *rate* of diverges of CS_{PIR} from its Steady-State CS (CS_{SS}) to trigger a PIR event.

The IQS680 PIR event threshold ranges from 0 - 255, which is chosen to obtain the desired sensitivity and noise immunity for the PIR sensor. A PIR Event is triggered if the Positive Delta Sum (PDS) or Negative Delta Sum (NDS) is greater than the product of the PIR Threshold Scale Factor (0x93) and the PIR Enter Event Threshold (0x91).

$$(PIR_{NDS}\, or\, PIR_{PDS}) > PIR_{Enter} \times PIR_{Scale}$$

Before another event can be triggered the Positive Delta Sum (PDS) or Negative Delta Sum (NDS) needs to be below the product of the PIR Threshold Scale Factor (0x93) and the PIR Exit Event Threshold (0x92) value.

$$(PIR_{NDS}\, or\, PIR_{PDS}) < PIR_{Exit} \times PIR_{Scale}$$

PIR Exit Event Threshold (0x91) should be less than or equal to PIR Enter Event Threshold (0x92).

$$PIR_{Enter} \leq PIR_{Exit}$$

5.9 PIR ATI threshold

The PIR sensor is susceptible to ambient noise such as fluctuation in temperature over the course of 24 hours. These changes directly impact the sensitivity of the sensor.

In order to maintain a non-variant sensitivity, the IQS680 will monitor the difference of the CS_{SS} value from the selected ATI target value and compare it to the PIR ATI Threshold (ATI_{THR}) to determine if the device will recalibrate the PIR sensor.

$$CS_{SS} \geq \frac{\mathrm{ATI_{THR}}}{255} \times ATI_{\mathrm{Target}}\,,$$

There are various possible values for ATI_{THR}, some are given in the table below.

Table 5-5: PIR deviation thresholds

ATI_{THR}: PIR ATI THR select	
16	More conservative
24	
32	Less conservative

The PIR ATI threshold can be set in the Ch1 ATI Threshold (0x47) register.

5.10 Number of PIR events

In order to improve the IQS680's resilience against false triggers (important for security applications), the device can be set up to prevent the output from activating until a given number of PIR events has occurred in short succession. The number of events may range from 1 to 4. The number of PIR events can be set in the PIR Settings 0 (0x90, bit4-5) register.

5.11 PIR Trigger Time Out

If a PIR event has occurred, given that the output is in a load driven mode, the device's output will go in an active or PWM state for a selected period. This period can be selected in steps of 4.2 seconds, ranging from 4.2 to 1071 seconds. The PIR Trigger Time Out can be set in PIR Trigger Time Out (0xD9) register.

When a consecutive PIR event occur before the selected period has elapsed, the internal timer will reset and the output will remain active. This implies that the PIR Trigger Time Out defines the time the output will remain active after the last PIR event has occurred.

5.12 Minimum PIR Stabilization Time

Due to the unknown nature of the PIR state at the moment the device receives power, it is necessary for the IQS680 to suppress all PIR events at start-up. The IQS680 automatically monitors the PIR sensor and continue to suppress all PIR events until the sensor has stabilized. This can take up to 30 seconds.

The Minimum PIR stabilization time defines the period which the PIR must be stable before the IQS680 will stop suppressing PIR events. The Minimum PIR Stabilization Time can be set in seconds in the PIR Time Out Stabilise (0x95) register.

6 Device clock, power management and mode operation

6.1 Device main oscillator

The IQS680 has an **8MHz** main oscillator to clock all system functionality. The ProxFusion® channels charges at half of the main oscillator frequency. Therefore, the frequency multiplier selected in ProxFusion Settings 1 (0x53; bit 4-5) is multiplied by half of the main oscillator frequency.

6.2 Device modes

The IQS680 supports the following modes of operation;

- **Active Power mode** (Increased report rate)
- **Low Power mode** (Fixed report rate)

The device will automatically switch between the different operating modes. The IQS680 is in a permanent low-power mode until the output is activated by an event. When the IQS680 switches to Active Power mode the Output Active flag will be set in the System Flags (0x11; bit 7) register.

6.2.1 Active Power mode

Active Power mode is the fully active sensing and load driving mode to function when an event has activated the output. A sample period adjustment can be specified in the Active Sample Period Adjustment (0xD4) register. The designer may select 1 of 4 possible sample frequencies as shown in Table 5-1.

6.2.2 Low Power mode

Low Power mode is the fully active sensing mode to function at a fixed report rate specified in the Sample Period (0xD5) register. The designer may select 1 of 4 possible sample frequencies as shown in Table 5-1. Reduced report rates also reduce the current consumed by the sensor.

6.2.3 Active time

The amount of time the IQS680 is in active power mode is determined by the PIR Trigger Time Out (0xD9). The PIR Trigger flag will be cleared after this time and the IQS680 will enter Low Power Mode.

6.3 Streaming and Standalone mode:

Standalone mode is the default. Streaming mode can be enabled by writing to the EEPROM as explained in Chapter 8 or by using the GUI.

6.3.1 Streaming mode

The ready is triggered every cycle and per the report rate. Data can be streamed or settings can be changed using the I2C communication interface.

6.3.2 Standalone mode

The ready is triggered only when an event has occurred.

Settings stored on the EEPROM are loaded at POR. The device operates in standalone mode without the need for an MCU

The events which trigger the ready:

- PIR event trigger
- Touch or proximity events on channel 0 or 2

Note: Both these events have built in hysteresis which filters out very slow changes

7 Communication

The **IQS680** device interfaces to a master controller via a 3-wire (SDA, SCL and RDY) serial interface bus that is I²C™ compatible with a maximum communication speed of 400 kHz. The communications interface of the IQS680 supports the following:

- Streaming data as well as standalone mode.
- The master may address the device at any time (if in streaming mode). If the IQS680 is not in a communication window, the device returns an ACK after which clock stretching is induced until a communication window is entered. Additional communication checks are included in the main loop to reduce the average clock stretching time.
- The provided interrupt line (RDY) is open-drain **active high** implementation and indicates a communication window.

7.1 Control Byte

The Control byte indicates the 7-bit device address (44H default) and the Read/Write indicator bit. The structure of the control byte is shown in Figure 7.1.

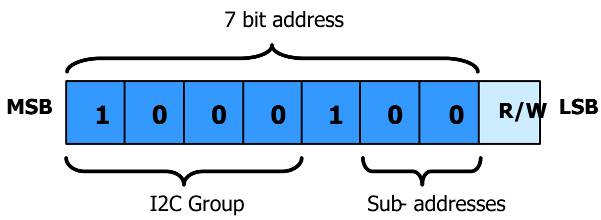


Figure 7.1: IQS680 Control Byte

The I²C device has a 7-bit Slave Address (default 0x44H) in the control byte as shown in 0. To confirm the address, the software compares the received address with the device address. Sub-address values can be set by OTP programming options.

7.2 I²C Read

To read from the device a *current address read* can be performed. This assumes that the address-command is already setup as desired.

Current Address Read

Start	Control Byte		Data n		Data n+1		Stop
S		ACK		ACK		NACK	S

Figure 7.2: Current Address Read

If the address-command must first be specified, then a *random read* must be performed. In this case a WRITE is initially performed to setup the address-command, and then a repeated start is used to initiate the READ section.

Random Read

Start	Control Byte		Address-command		Start	Control Byte		Data n		Stop
S	Adr + WRITE	ACK		ACK	S	Adr + READ	ACK		NACK	S

Figure 7.3: Random Read

7.3 I²C Write

To write settings to the device a *Data Write* is performed. Here the Address-Command is always required, followed by the relevant data bytes to write to the device.

DATA WRITE

Start	Control Byte		Address-Command		Data n		Data n+1		Stop
S	Adr + WRITE	ACK		ACK		ACK		ACK	S

Figure 7.4: I²C Write.

7.4 End of Communication Session / Window

Similar to other Azoteq I²C devices, to end the I²C communication session, a STOP command is given. When sending numerous read and write commands in one communication cycle, a repeated start command must be used to stack them together (since a STOP will jump out of the communication window, which is not desired).
The STOP will then end the communication, and the IQS680 will return to process a new set of data. Once this is obtained, the communication window will again become available (RDY set LOW).

7.5 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 Bank2 (bit0-bit7) = SUB_ADDR_0** to **SUB_ADDR_255.**

a) Default address: 0x44 = DEFAULT_ADDR (0x44) **OR** SUB_ADDR_0 (00000000b)
b) Sub-address: 0x45 = DEFAULT_ADDR (0x44) **OR** SUB_ADDR_1 (00000001b)
c) Sub-address: 0x46 = DEFAULT_ADDR (0x44) **OR** SUB_ADDR_2 (00000010b)
d) Etc.

7.6 Additional OTP options

All one-time-programmable device options are located in FG bank 3.

Floating Gate Bank3								
Bit Number	7	6	5	4	3	2	1	0
Name	Reserved						I2C slave	EEPROM Read
Default	XX	XX	XX	XX	XX	XX	0	1

Bit definitions:

- Bit 0: EEPROM Read
  - 0: Disable EEPROM Read
  - 1: Enable EEPROM Read
- Bit 1: I2C slave
  - 0: Standalone/GPIO mode
  - 1: I2C enabled on IQS680
- Bit 2-7: Reserved
  - XX: Do not change these bits. The IQS680 will not function properly.

7.7 I²C Specific Commands

7.7.1 Show Reset

After start-up, and after every reset event, the "Show Reset" flag will be set in the Event Flags register (0x10; bit 7).

The "Show Reset" bit can be read to determine whether a reset has occurred on the device (it is recommended to be continuously monitored). This bit will be set '1' after a reset.

The "Show Reset" flag will be cleared (set to '0') by writing a '1' into the "Ack Reset" bit in the I²C Command register (0xD0; bit 0) . A reset will typically take place if a timeout during communication occurs.

7.8 I²C I/O Characteristics

The **IQS680** requires the input voltages given in Table 7-1, for detecting high ("1") and low ("0") input conditions on the I²C communication lines (SDA, SCL and RDY).

Table 7-1 IQS680 I²C Input voltage

	Input Voltage (V)
Vin_{LOW}	0.3*VDDHI
Vin_{HIGH}	0.7*VDDHI

Table 7-2 provides the output voltage levels of the IQS680 device during I²C communication.

Table 7-2 IQS680 I²C Output voltage

	Output Voltage (V)
$Vout_{LOW}$	GND +0.2 (max.)
$Vout_{HIGH}$	VDDHI – 0.2 (min.)

7.9 Recommended communication and runtime flow diagram

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

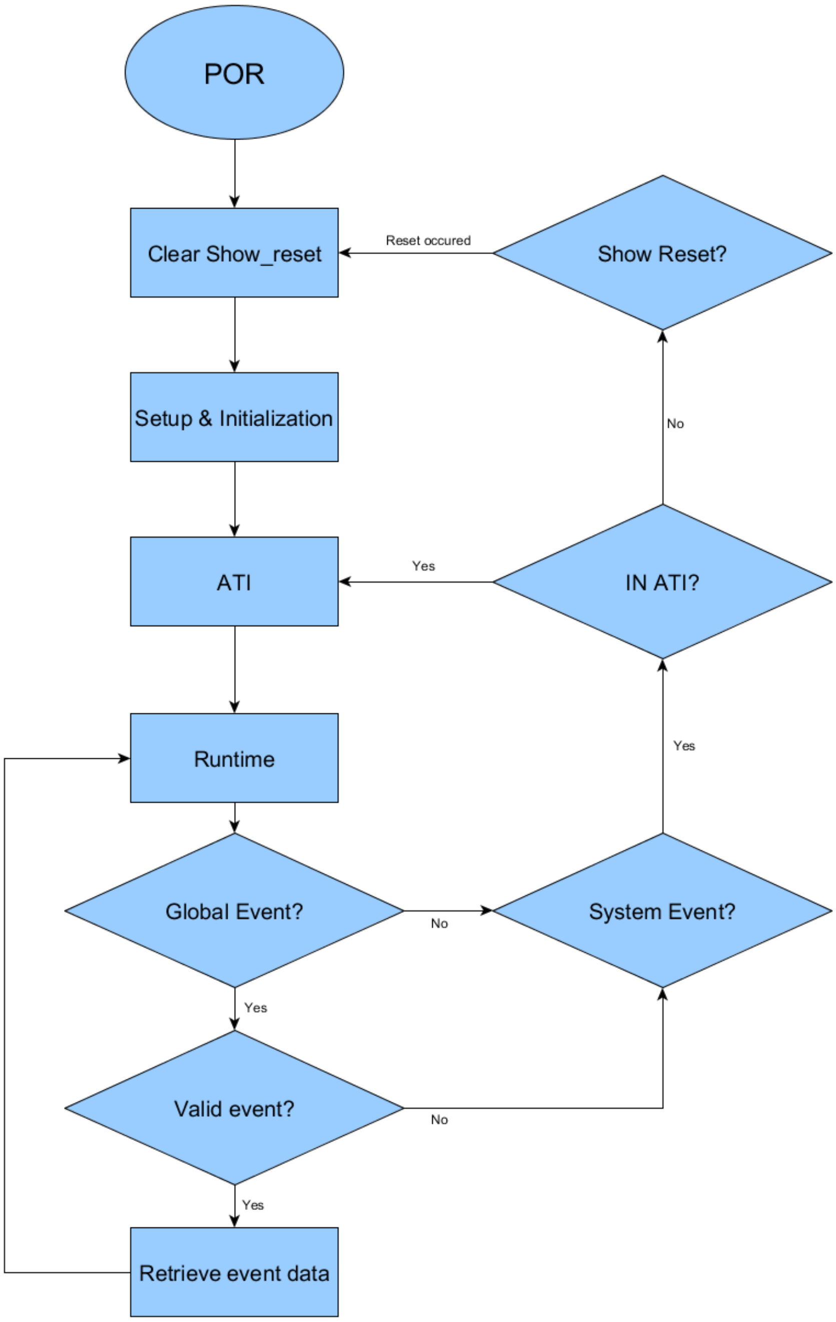


Figure 7.5 Master command structure and runtime event handling flow diagram

It is recommended that the master verifies the status of the Flag Registers (0x10 – 0x13) bits to identify events and resets. Detecting either one of these should prompt the master to the next steps of handling the IQS680.

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

Standalone mode communication is recommended for runtime use of the IQS680. Streaming mode communication is used for detail sensor evaluation during prototyping/development.