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IQS266 Datasheet

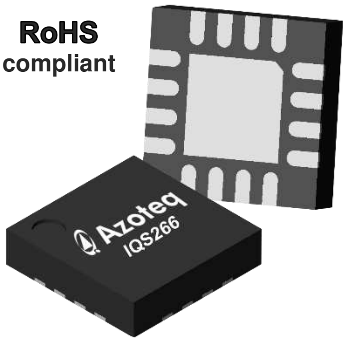
2x3 Channel projected capacitive trackpad controller with self-capacitive wake-up

The IQS266 ProxSense® IC is a 2x3 projected capacitive trackpad designed for low power mobile applications. This trackpad is perfect to implement on a single sided ITO touch screen for wearables. A self-capacitive channel is used for wake-up which keeps the power consumption in low-power less than 5 uA. Other features include automatic tuning for sense electrodes, internal reference capacitor and internal regulator to reduce total system cost.

Features

- **Capacitive sensing**
  - Parasitic capacitive load cancellation
  - Fully adjustable sensing options
  - Self capacitive prox channel (CH0)
  - 2x3 Projected capacitive trackpad (CH1-6)
- **Zoom and Low power options for minimal power consumption**
- **Multiple integrated UI** options based on years of experience in sensing on fixed and mobile platforms:
  - **Proximity / Touch**
  - **Proximity wake-up from low power** using distributed proximity channel
  - **Gesture recognition**:
    - Swipes: Up, down, left, right (segment indication for left & right swipes)
    - Adjustable swipe length and time limitations
    - Taps: Single taps with segment indication
    - Adjustable tap size and time limitation
- **A**utomatic **T**uning **I**mplementation (**ATI**)
- Minimal external components
- Fast **I²C** compatible interface
- **RDY indication** for event mode operation
- **Event or Streaming mode**
- **Small package size: QFN(3x3)-16**
- **Supply voltage: 1.8V to 3.3V**

RoHS
compliant



QFN(3x3)-16 package
Representation only

Applications

- Wearables
- Navigational controls
- White goods and appliances
- Office equipment, toys, sanitary ware
- Proximity detection that enables backlighting activation (Patented)
- Wake-up from standby applications
- Replacement for electromechanical switches and keypads
- GUI trigger and GUI control proximity detection
- Electronic Keypads or Pin pads

Available Packages	
T_A	**QFN(3x3)-16**
-20°C to 85°C	IQS266

Table of Contents

List of abbreviations

ATI	– Automatic Tuning Implementation
AC	– Alternating Current
ACF	– AC Filtered Counts
CH	– Channel
CS	– Sampling capacitor
CX	– Self capacitive electrode
I²C	– Inter-Integrated Circuit
LTA	– Long Term Average
N/C	– Not connect
NM	– Normal Mode
LP	– Low Power
RX	– Receiving electrode
RDY	– Ready interrupt signal
SCL	– I²C serial clock signal
SDA	– I²C serial data signal
TX	– Transmitting electrode

1 Introduction

1.1 Functional overview

The **IQS266** is a single self capacitive proximity and 6 channel projected trackpad sensor featuring an internal voltage regulator and reference capacitor (C_S).

The device has 6 pins for the connection of sense electrodes, which consist of 1 self electrode, for proximity wake-up, as well as 2 receivers and 3 transmitters, for a 2x3 trackpad. Three pins are used for serial data communication through the I^2C^{TM} compatible protocol, including an optional RDY pin.

The device automatically tracks slow varying environmental changes via various filters, detects swipe and tap gestures in various directions and segments on the trackpad. The device is equipped with an Automatic Tuning Implementation (ATI) to adjust the device for optimal sensitivity.

1.2 Packaging and Pin-Out

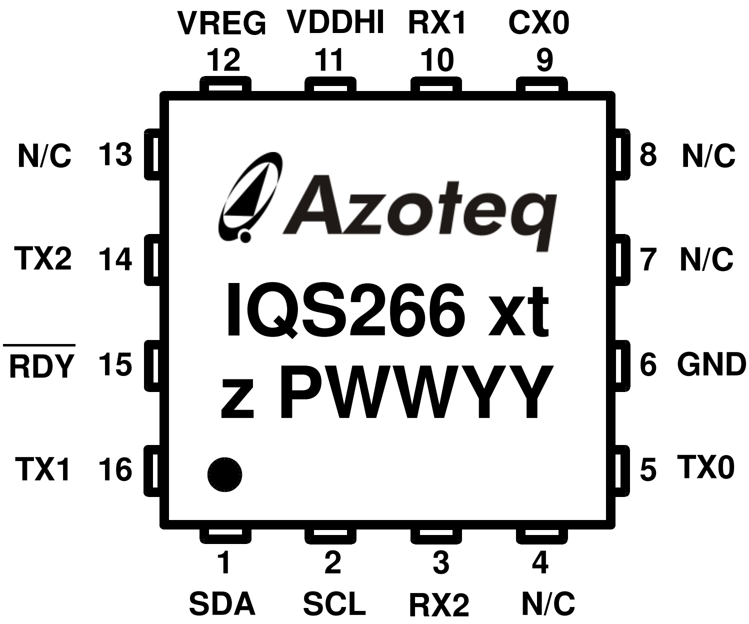


Figure 1.1 IQS266 Pin layout (representation only device marking differs)

Table 1.1 IQS266 Pin-out

Pin	Name	Type	Function
1	SDA	Digital	I²C Serial Data
2	SCL	Digital	I²C Serial Clock
3	RX2	Analogue	Receive Electrode
4	N/C	-	Not Connected
5	TX0	Transmitter	Transmit Electrode
6	GND	Supply Input	GND Reference
7	N/C	-	Not Connected
8	N/C	-	Not Connected
9	CX0	Analogue	Receive Electrode
10	RX1	Analogue	Receive Electrode
11	VDDHI	Supply Input	Supply Voltage Input
12	VREG	Analogue Output	Internal Regulator Pin (connect 1µF capacitor)
13	N/C	-	Not connected
14	TX2	Transmitter	Transmit electrode
15	RDY	Digital Output	Serial Ready Interrupt
16	TX1	Transmitter	Transmit electrode

1.3 Reference Design

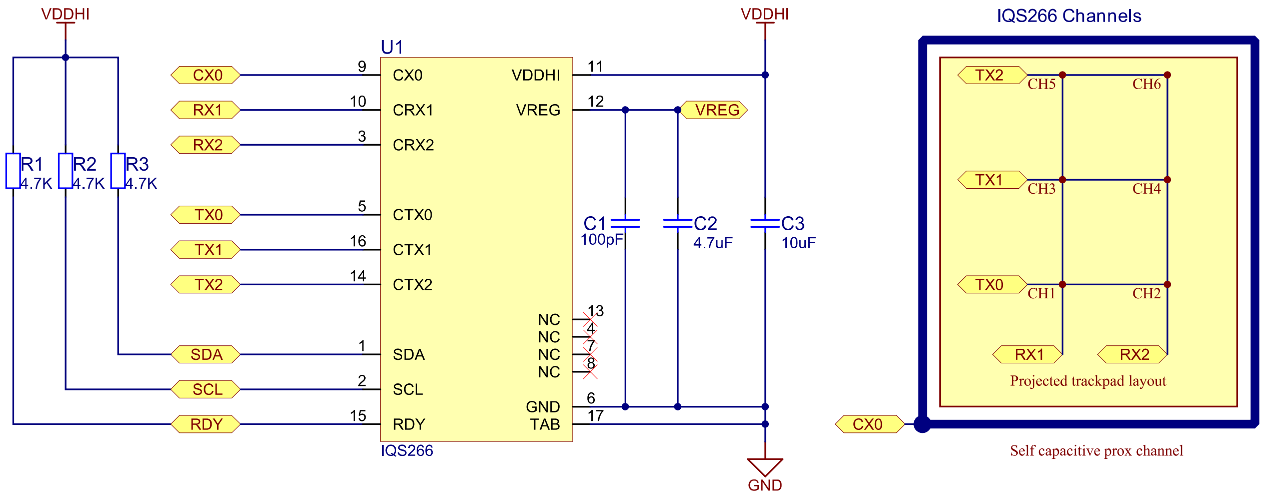


Figure 1.2 IQS266 Reference Design

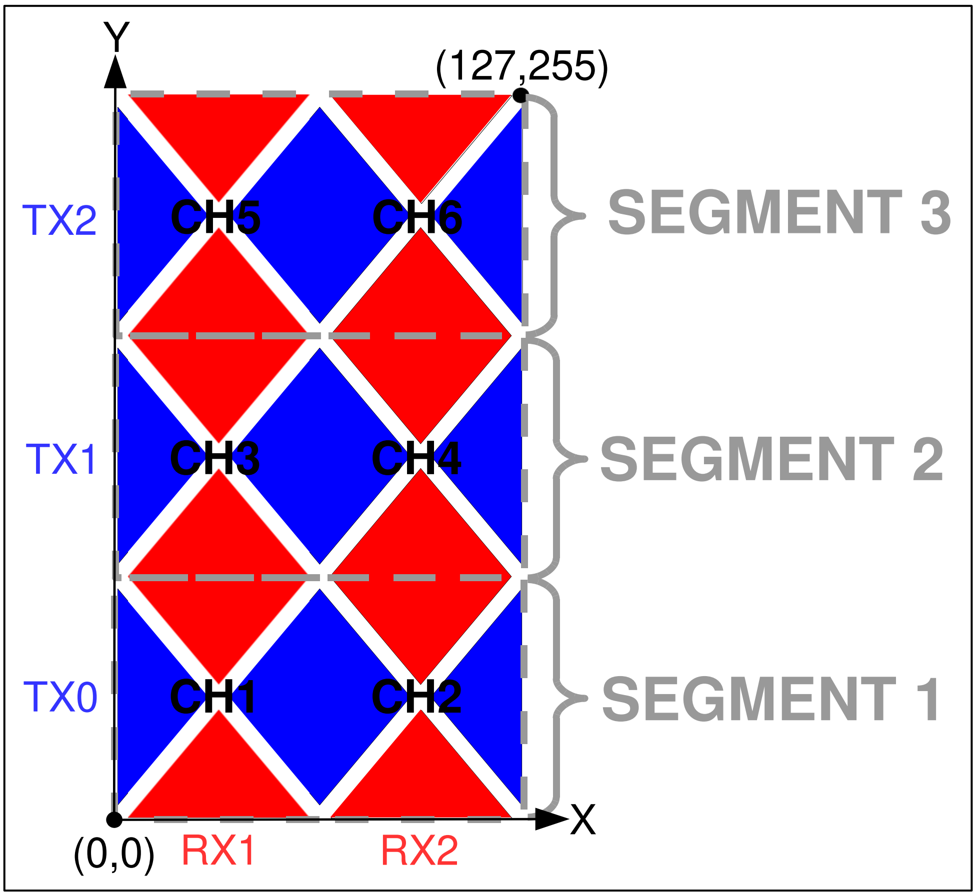


Figure 1.3 IQS266 Recommended trackpad layout (top view) with coordinate system and segment allocation

2 User configurable options

2.1 ProxSetting0

2.1.1 Disable ATI

The **IQS266** can automatically retune sensor electrodes when the counts drift outside a pre-defined ATI band. This allows the **IQS266** to keep optimal sensitivity during different environment. To disable the feature, the "ATI OFF" bit needs to be set in the ProxSettings0 register (0x80; byte 0). Disabling this feature only disables the automatic retuning; the MCU can at any time still force retuning with the Redo-ATI command.

2.1.2 Partial ATI

If it is required to have the ATI time reduced, the **IQS266** can use partial ATI by setting the "ATI Partial" bit in the ProxSettings0 register (0x80; byte 0). The designer must also specify the sensitivity multiplier (option 1 to 4) as the **IQS266** will only calculate the compensation multiplier and compensation. The Partial ATI option reduces start-up and re-tuning times, but does require the designer to verify that the base values achieved are within the desired range.

2.1.3 ATI Band

The user has the option to select the re-tuning band as ¼ of the ATI target (default is 1/8 of the ATI target) if it is desired to have a wider range for the counts to drift with environmental change before the device retune the electrodes. The wider band is achieved by setting the "ATI BAND" bit in the ProxSettings0 register (0x80; byte 0).

2.1.4 Redo-ATI

The **IQS266** can be forced to ATI at any time, regardless of present events. To force retuning set the "Redo ATI" bit in the ProxSettings0 register (0x80; byte 0). The "Redo ATI" bit will automatically clear after having been set.

2.1.5 Reseed

The **IQS266** LTA filters can be reseeded to the count values at any time to clear any output event. If count values are outside the ATI band, retuning will be triggered. To reseed set the "Reseed" bit in the ProxSettings0 register (0x80; byte 0). The "Reseed" bit will automatically clear after having been set.

Setting the Reseed bit will shift all LTA filters to a value of LTA_{new} = CS + 8 (CS – 8 for Self). The LTA will then track the CS value until they are even.

Performing a reseed action on the LTA filters, will effectively clear any proximity and/or touch conditions that may have been established prior to the reseed call.

2.1.6 Debug ATI

In order to facilitate faster start-up and re-tuning times, the communication windows are stopped during ATI on the **IQS266.** If the designer would like to be able to read data after every charge cycle during ATI, the communication can be enabled by setting the "Debug ATI" bit in the ProxSettings0 register (0x80; byte 0). A communication window can still be forced by the MCU with a RDY handshake (pulling the RDY line low) at any time even if the "Debug ATI" bit is not set.

2.1.7 Increase stability

The **IQS266's** analogue circuitry settling time can be increased (at the cost of higher current consumption) in order to have a more stable conversion in respect to the internal regulator. The longer settling time is enabled by setting the "Increase stability" bit in the ProxSettings0 register (0x80; byte 0).

2.1.8 Force Halt

The user has the option to halt the LTA to avoid any reseed or re-tuning events from taking place. This can be used in situations where the counts are expected to go in the wrong direction as a result of a controlled action in the application. To freeze the LTA filters set the "Force Halt" bit in the ProxSettings0 register (0x80; byte 0).

2.2 ProxSettings1

2.2.1 Comms WDT off

The WDT (watchdog timer) is used to reset the IC if a problem (for example a voltage spike) occurs during communication. The WDT will time-out (and thus reset the device) after t_{WDT} if no valid communication occurred during this time.

The WDT can be disabled during development by setting the "WDT Off" bit in the ProxSettings1 register (0x80; byte 1). It is not recommended to disable the WDT for production.

2.2.2 Event Mode

By default, the device operates in full streaming mode. There is an option for an event-driven I²C communication mode (also called "Event Mode"), with the RDY pin ONLY indicating a communication window after a prescribed event has occurred.

These events include:

- LP (low power) event
- Swipes (up / down / left / right)
- Tap
- ATI
- TP (trackpad) event
- Touch
- Proximity

The RDY pin will indicate events in the following manner:

1. **LP event:** Single RDY low on LP entry and again on exit
2. **Swipe Detected:** Single RDY low on swipes
3. **Tap Detected:** Single RDY low
4. **ATI:** RDY low on ATI start & again on ATI completing
5. **TP event:** RDY pin low after completion of every charge cycle while a touch remains detected on a channel.
6. **Touch:** RDY low on each touch entry and exit occurring.
7. **Prox:** RDY low on entry and exit

For trackpad events, the device will stream data continuously (after every charge cycle) when a touch is present on one of the channels, even if Event Mode is enabled.

Event Mode can be enabled by setting the "Event Mode" bit in the ProxSettings1 register (0x80; byte 1).

Note: The device is also capable of functioning **without** a RDY line on a polling basis.

2.2.3 LTA Beta

The speed at which the LTA will follow the counts when no event is present (no filter halt) can be changed by adjusting the beta values for the LTA filter. Four options are available by setting the "LTA Beta" bits in the ProxSettings1 register (0x80; byte 1).

2.2.4 AC Filter

The AC filter is implemented to provide better stability of Counts (CS) in electrically noisy environments.

The filter also enforces a longer minimum sample time for detecting proximity events on CH0, which will result in a slower response rate when the device enters low power modes. The filter can be disabled.

The count filter is implemented on all channels, to aid in the trackpad coordinate calculations, but touch events are (by default) determined on unfiltered count values.

The count filter can be disabled, or the speed (amount of filtering) adjusted by setting the "ACF" bits in the ProxSettings1 register (0x80; byte 1).

2.3 ProxSettings2

2.3.1 Wake both directions

The **IQS266** can wake from low power in both directions of count movement (of the proximity threshold). This could be used to sense release events from low power mode. To enable sensing in both directions, set the "Wake both dir" bit in the ProxSettings2 register (0x81; byte 0).

2.3.2 Clear TP flags

If the **IQS266** outputs a TP event by setting a TP flag, the flag will remain set until the TP flags register is read. To clear the TP flags with each new conversion set the "Clear TP flags" bit in the ProxSettings2 register (0x81; byte 0).

2.3.3 NP segment rate

The **IQS266** does a NP (normal power) conversion during low power where all active channels are charged even though the IC are only monitoring CH0 for a wake-up event. To change the rate of the NP segments, configure the lower three bits called "NP segment rate" in the ProxSettings2 register (0x81; byte 0). The rate is calculated as a desired fraction of the "Low power period"

2.4 ProxSettings3

2.4.1 ACK Reset

After start-up, and after every reset event, the “Show Reset” flag will be set in the System Flags register (0x01; byte 0).

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 bit will be cleared (set to ’0’) by writing a ’1’ into the “ACK Reset” bit in Prox settings 3 register (0x81; byte 1). A reset will typically take place if a timeout during communication occurs.

2.4.2 Off mode

The **IQS266** has the option to switch the device off during inactive states of operation. The device will only wake up again on activity on the SDA line (all device register memory will be lost). A reset will occur when the device wakes up and the IC needs to be setup again. This is suitable for applications that require no device operation during defined operation states. To switch to off mode set the “Off mode” bit in the ProxSettings3 register (0x81; byte 1).

2.4.3 Projected Bias

The **IQS266** has the option to change the bias current of the transmitter during projected sensing mode. A larger bias current is required when using larger electrodes, but will also increase the IC power consumption. The bias current is default on 5µA, and can be changed to 10µA. To select 10 µA set the “Proj Bias” bit in the ProxSettings3 register (0x81; byte 1).

2.4.4 Float CX

During the charge transfer process, the channels (CX0 electrode for CH0 Self or Rx electrodes for projected trackpad channels) that are not being processed during the current conversion are effectively grounded to decrease the effects of noise-coupling between the sense electrodes. Grounding these traces is useful in applications with long tracks between IC and sense electrode.

There is the option to float the CX (or Rx) lines in between charging. This is particularly useful for applications with a self-capacitive CH0 button with a thick overlay, where more sensitivity is required, or in application that need to avoid false triggers from water on the overlays. To float channels set the “Float Cx” bit in the ProxSettings3 register (0x81; byte 1).

2.4.5 Halt charge

The charging sequence of the **IQS266** can be halted on command. This function is useful for applications where the IQS266 can be completely halted without resetting the registers. To enable “Halt charge” set bit in the ProxSettings3 register (0x81; byte 1). To disable “Halt charge” toggle the RDY line. LP period register (0x84; byte 1) should be greater than 0 when “Halt charge” is activated.

2.4.6 CH0 distributed

The **IQS266** device by default performs a self capacitive conversion for channel 0 on the CX0 pin. An option bit is provided to change channel 0 to a distributed self capacitive prox channel charging on pins CX0, RX1 & RX2 simultaneously. No conversion will then take place on the CX0 pin. To enable this function for channel 0 set the “CH0 distributed” bit in the ProxSettings3 register (0x81; byte 1).

2.4.7 Charge transfer frequency slow CH1 – 6

The **IQS266** can reduce the charge transfer frequency for applications that require extra sensitivity (for example very thick overlays). The charge transfer frequency can be halved. The default charge transfer frequency for projected operation is 2MHz and can be slowed down to 1MHz by setting the “Xfer slow CH1 – 6” bit in the ProxSettings3 register (0x81; byte 1).

2.4.8 Charge transfer frequency slow CH0

The **IQS266** can reduce the charge transfer frequency for applications that require extra sensitivity (for example very thick overlays). The charge transfer frequency can be halved. The default charge transfer frequency for self capacitive operation is 1MHz and can be slowed down to 500kHz. If the channel 0 distributed setting is used the charge transfer frequency for the projected operation is 2MHz and can be slowed down to 1MHz by setting the “Xfer slow

CH0” bit in the [ProxSettings3 register (0x81; byte 1)].

2.5 Event mask

The **IQS266** can be configured to report only desired events by masking out unwanted events from the [Events register (0x01; byte 1).] This is only applied during event mode and is particularly useful where communication is only required on certain desired events while still having the **IQS266** waking from low power and sensing as required without interrupting the master/MCU. Clearing the corresponding bits in the [Event mask register (0x82; byte 0)] will disable or mask an event from reporting during event mode.

2.6 Zoom timeout

A zoom mode is defined for the **IQS266** during which normal power conversions is performed to have an increased performance on all channels. A zoom timeout is used to fix a desired amount of time to remain in this mode for no active events before switching to low power. The zoom timeout can be set in decimal of 500ms. Any event triggered before timeout occurs will clear the timer and start timing again from the last reported event. Configure [Zoom timeout register (0x82; byte 1)].

2.7 Halt timeout

The LTA filter for all channels will halt on proximity or touch events. A halt timeout is implemented for the **IQS266** to terminate a halted filter condition to ensure that no stuck conditions remain indefinitely active. A halt timeout occurs during a stationary touch or prox condition on one or more channels without any change in events/flags for the configured timeout period. After timeout is reached a redo ATI command is self-induced by the **IQS266** in order to recalibrate all channels and clear any stuck activations. The halt timeout can be set in decimal increments of 500ms. Any additional event triggered or active event cleared before timeout occurs will clear the timer and start timing again. Configure [Halt timeout register (0x83; byte 0)].

2.8 RDY timeout

If no communication is initiated from the master/host MCU within the first t_{COMMS} (t_{COMMS} = 2.56ms default) of the RDY line indicating that data is available (i.e. RDY = low), the device will resume with the next cycle of charge transfers and the data from the previous conversions will be lost. The timeout time is adjustable in steps of 0.64ms in the [RDY timeout register (0x83; byte 1).] There is also a timeout (t_{I2C}) that cannot be disabled, for when communication has started but not been completed, for example when the bus is being held by another device. t_{I2C} = 62ms.

2.9 Normal mode (NM) period

The **IQS266** normal mode period specifies the sampling time for normal mode conversions (fastest possible conversion period for all channels active). The default normal mode period is 10ms and can be configured in increments of 1ms using the [NM period register (0x84; byte 0)].

2.10 Low power (LP) period

The LP period of the **IQS266** specifies the sampling time for channel 0 during low power mode. By default, the low power mode period is equal to zero which means that the **IQS266** will not enter low power. For any other configured period in increments of 16ms, low power will be entered upon zoom timeout and use that sampling period. Use the [LP period register (0x84; byte 1)] to configure the low power sampling period of channel 0. The VREG voltage should not drop with more than 50 mV. A bigger capacitor on VREG can be used for longer LP periods.

2.11 Proximity threshold CH0

A proximity threshold for channel 0 can be selected for the application, to obtain the desired proximity trigger level. The proximity threshold is selectable between 1 (most sensitive) and 255 (least sensitive) counts. These threshold values (i.e. 1-255) are specified in Counts (CS) in the Proximity threshold CH0 register (0x85; byte 0). The default proximity threshold is 6 counts. For a proximity threshold, higher than CH0 touch threshold a proximity event will be forced during a touch.

2.12 Touch Thresholds

A touch threshold for each channel can be selected by the designer to obtain the desired touch sensitivity and is selectable between 1/256 (most sensitive) to 255/256 (least sensitive). The touch threshold is calculated as a fraction of the Long-Term Average (LTA) given by,

$$T_{THR} = {}^{x}/_{256} \times LTA$$

With lower target values (therefore lower LTA's) the touch threshold will be lower and vice versa.

Individual touch thresholds can be set for each channel (including channel 0), by writing to the touch threshold registers. Registers start from 0x85; byte 0 and continues to 0x88; byte 1 for channels 0 to 6. The default touch threshold is 40/256 times the LTA.

2.13 ATI target

The **IQS266** ATI targets for channel 0 and all the other channels (1-6) can be adjusted independently. The ATI target should be selected during product design and development and corresponding prox and touch thresholds should be selected and evaluated according to the desired target value. The ATI target can be adjusted in multiple increments of 8 counts (0-255 * 8counts) using either ATI target CH1-6 register (0x89; byte 0) or ATI target CH0 (0x89; byte 1).

2.14 Base values

The **IQS266** has the option to change the base value of the proximity channel (CH0) and the trackpad channels (CH1 to CH6) during the Full ATI algorithm. This provides the user with another option to select the sensitivity of the **IQS266** without changes in the hardware (RX/TX sizes and routing, etc.).

The base values are set by writing to the Base value register (0x8A; byte 0). There are 16 different options to choose from. To choose a custom base value, select partial ATI.

The base value influences the overall sensitivity of the channel and establishes a base count from where the ATI algorithm starts executing. A lower base value will typically result in a higher sensitivity of the respective channel, as lower multipliers will be selected, and more compensation would be required.

3 Communication

The **IQS266** 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 400kbit/s.

3.1 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 3.1.

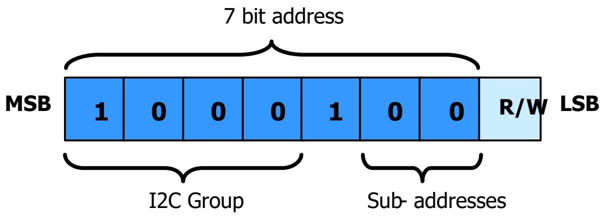


Figure 3.1 IQS266 Control Byte.

The I²C device has a 7-bit Slave Address (default 0x44H) in the control byte as shown in Figure 3.1. To confirm the address, the software compares the received address with the device address. Sub-address values can be set by OTP programming options.

3.2 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 3.2 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 3.3 Random Read

3.3 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 3.4 I²C Write

3.4 End of Communication Session / Window

Similar to other Azoteq I^2C devices, to end the I^2C communication session, a STOP command must be issued. 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 **IQS266** will return to process a new set of data. After the conversion, the communication window will again become available (RDY set LOW; after each conversion during streaming mode operation; only after an event detection during event mode operation).

3.5 I²C Sub-address

The **IQS266** has four available sub addresses, 44H (default) to 47H, which allows up to four devices on a single I²C bus.

3.5.1 Internal sub-address selection

Selecting the sub-address via OTP bits allows the user 4 different options:

Table 3.1 I²C sub-address selection

FG25	FG26	Device Address
0	0	0x44
0	1	0x45
1	0	0x46
1	1	0x47

3.6 RDY Hand-Shake Routine

The master or host MCU has the capability to request a communication window at any time, by pulling the RDY line low. The communication window will open directly following the current conversion cycle. For more details please refer to the communication interface guide.

3.7 I²C Specific Commands

3.7.1 Show Reset

After start-up, and after every reset event, the "Show Reset" flag will be set in the System Flags register (0x01H; byte 0).

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 bit will be cleared (set to '0') by writing a '0' into the "Show Reset" bit. A reset will typically take place if a timeout during communication occurs.

3.7.2 I2C Timeout

If no communication is initiated from the master/host MCU within the first t_{COMMS} (t_{COMMS} = 2.56 ms default) of the RDY line indicating that data is available (i.e. RDY = low), the device will resume with the next cycle of charge transfers and the data from the previous conversions will be lost. The timeout time is adjustable in steps of 0.64ms in the RDY timeout register (0x83; byte 1). There is also a timeout (t_{I2C}) that cannot be disabled, for when communication has started but not been completed, for example when the bus is being held by another device. t_{I2C} = 62ms.

3.8 I²C I/O Characteristics

The **IQS266** requires the input voltages given in Table 3.2, for detecting high ("1") and low ("0") input conditions on the I²C communication lines (SDA, SCL and RDY).

Table 3.2 IQS266 I²C Input voltage

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

Table 3.3 provides the output voltage levels of the IQS266 device during I²C communication.

Table 3.3 IQS266 I²C Output voltage

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

4 Memory map

Table 4.1 IQS266 Memory map index

Full Address	Byte offset	Group Name	Item Name	Data Access
0x00	0	Device info	PRODUCT_NUM	Read-Only
	1		VERSION_NUM	Read-Only
0x01	0	Flags	SYSFLAGS0	Read-Only
	1		EVENTS	Read-Only
0x02	0	Trackpad data	TP_FLAGS	Read-Only
	1		Reserved	Read-Only
0x03	0		X_CURR	Read-Only
	1		Y_CURR	Read-Only
0x04	0	Prox & Touch data	PROX_CHANNEL0	Read-Only
	1		TOUCH_CHANNELS	Read-Only
0x05	0	ACF data	ACF_CH0_LOW	Read-Only
	1		ACF_CH0_HIGH	Read-Only
0x06	0		ACF_CH1_LOW	Read-Only
	1		ACF_CH1_HIGH	Read-Only
0x07	0		ACF_CH2_LOW	Read-Only
	1		ACF_CH2_HIGH	Read-Only
0x08	0		ACF_CH3_LOW	Read-Only
	1		ACF_CH3_HIGH	Read-Only
0x09	0		ACF_CH4_LOW	Read-Only
	1		ACF_CH4_HIGH	Read-Only
0x0A	0		ACF_CH5_LOW	Read-Only
	1		ACF_CH5_HIGH	Read-Only
0x0B	0		ACF_CH6_LOW	Read-Only
	1		ACF_CH6_HIGH	Read-Only
0x0C	0	LTA data	LTA_CH0_LOW	Read-Only
	1		LTA_CH0_HIGH	Read-Only
0x0D	0		LTA_CH1_LOW	Read-Only
	1		LTA_CH1_HIGH	Read-Only
0x0E	0		LTA_CH2_LOW	Read-Only
	1		LTA_CH2_HIGH	Read-Only
0x0F	0		LTA_CH3_LOW	Read-Only
	1		LTA_CH3_HIGH	Read-Only
0x10	0		LTA_CH4_LOW	Read-Only
	1		LTA_CH4_HIGH	Read-Only
0x11	0		LTA_CH5_LOW	Read-Only
	1		LTA_CH5_HIGH	Read-Only
0x12	0		LTA_CH6_LOW	Read-Only
	1		LTA_CH6_HIGH	Read-Only
0x13	0	Deltas	DELTA_CH0_LOW	Read-Only
	1		DELTA_CH0_HIGH	Read-Only
0x14	0		DELTA_CH1_LOW	Read-Only
	1		DELTA_CH1_HIGH	Read-Only
0x15	0		DELTA_CH2_LOW	Read-Only
	1		DELTA_CH2_HIGH	Read-Only
0x16	0		DELTA_CH3_LOW	Read-Only
	1		DELTA_CH3_HIGH	Read-Only
0x17	0		DELTA_CH4_LOW	Read-Only
	1		DELTA_CH4_HIGH	Read-Only
0x18	0		DELTA_CH5_LOW	Read-Only

	1		DELTA_CH5_HIGH	Read-Only
0x19	0		DELTA_CH6_LOW	Read-Only
	1		DELTA_CH6_HIGH	Read-Only
0x80	0	Prox settings	PROX_SETTINGS0	Read-Write
	1		PROX_SETTINGS1	Read-Write
0x81	0		PROX_SETTINGS2	Read-Write
	1		PROX_SETTINGS3	Read-Write
0x82	0	Event mask	EVENT_MASK	Read-Write
	1	Timeout periods	ZOOM_TIMEOUT	Read-Write
0x83	0		HALT_TIMEOUT	Read-Write
	1		RDY_TIMEOUT	Read-Write
0x84	0	Report rates	NM_PERIOD	Read-Write
	1		LP_PERIOD	Read-Write
0x85	0	Thresholds	PROX_THR_CH0	Read-Write
	1		TOUCH_THR_CH0	Read-Write
0x86	0		TOUCH_THR_CH1	Read-Write
	1		TOUCH_THR_CH2	Read-Write
0x87	0		TOUCH_THR_CH3	Read-Write
	1		TOUCH_THR_CH4	Read-Write
0x88	0		TOUCH_THR_CH5	Read-Write
	1		TOUCH_THR_CH6	Read-Write
0x89	0	Channel settings	ATI_TARGET_CH1-6	Read-Write
	1		ATI_TARGET_CH0	Read-Write
0x8A	0		BASE_VALUE_CH1-6_CH0	Read-Write
	1		ACTIVE_CHANNELS	Read-Write
0x8B	0	Tap gesture settings	TAP_TIMER_LIMIT	Read-Write
	1		TAP_THRESHOLD	Read-Write
0x8C	0	Swipe gesture settings	SWIPE_TIMER_LIMIT	Read-Write
	1		SWIPE_THRESHOLD	Read-Write
0x8D	0	Multipliers and compensation	SENS & COMP 0	Read-Write
	1		COMPENSATION 0	Read-Write
0x8E	0		SENS & COMP 1	Read-Write
	1		COMPENSATION 1	Read-Write
0x8F	0		SENS & COMP 2	Read-Write
	1		COMPENSATION 2	Read-Write
0x90	0		SENS & COMP 3	Read-Write
	1		COMPENSATION 3	Read-Write
0x91	0		SENS & COMP 4	Read-Write
	1		COMPENSATION 4	Read-Write
0x92	0		SENS & COMP 5	Read-Write
	1		COMPENSATION 5	Read-Write
0x93	0		SENS & COMP 6	Read-Write
	1		COMPENSATION 6	Read-Write

4.2 0x00 Device info

4.2.1 Product number

PRODUCT_NUM (0x00, offset 0)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	Product number							
Default	0	1	0	0	1	0	1	0
	0x4A = D'74							

Bit definitions:

- Bit 7-0: Device product number

4.2.2 Version number

VERSION_NUM (0x00, offset 1)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	Version Number							
Default	0	0	0	0	0	0	1	0
	0x02 = D'2							

Bit definitions:

- Bit 7-0: Device software version number

4.3 0x01 Flags

4.3.1 System flags

SYSFLAGS0 (0x01, offset 0)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	-	R	R	R	R
Name	SHOW RESET	NP_SEG LT_N_UP	ATI ERROR	-	NP SEG ACTIVE	IN ATI	IGNORE GLOBAL HALT	LP ACTIVE

Bit definitions:

- Bit 7: Show reset
  - 0: No reset event
  - 1: A device reset has occurred and needs to be acknowledged.
- Bit 6: NP segment LTA Update
  - 0: LTA updates enable
  - 1: LTA updates blocked
- Bit 5: ATI error
  - 0: No ATI error occurred
  - 1: An ATI error occurred
- Bit 3: NP segment active
  - 0: Normal power segment is inactive
  - 1: Normal power segment is active
- Bit 2: In ATI
  - 0: No channels are in ATI
  - 1: System is busy executing an ATI
- Bit 1: Ignore global halt
  - 0: Global halt is not ignored
  - 1: Global halt is ignored
- Bit 0: Low power active
  - 0: Low power mode is inactive
  - 1: Low power mode is active

4.3.2 Events

Events (0x01, offset 1)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	-	R	R	R	R	R	R
Name	LP EVENT	-	SWIPE EVENT	TAP EVENT	ATI EVENT	TP EVENT	TOUCH EVENT	PROX EVENT

Bit definitions:

- Bit 7: Low power event flag
  - 0: No event to report
  - 1: A low power event has occurred to signal low power mode entry
- Bit 5: Swipe event flag
  - 0: No event to report
  - 1: A swipe event has occurred and should be handled
- Bit 4: Tap event flag
  - 0: No event to report
  - 1: A tap event has occurred and should be handled
- Bit 3: ATI event flag
  - 0: No event to report
  - 1: An ATI event has occurred and should be handled
- Bit 2: Trackpad event flag
  - 0: No event to report
  - 1: A trackpad event has occurred and should be handled
- Bit 1: Touch event flag
  - 0: No event to report
  - 1: A touch event has occurred and should be handled
- Bit 0: Proximity event flag
  - 0: No event to report
  - 1: A proximity event has occurred and should be handled

4.4 0x02 – 0x03 Trackpad data

4.4.1 Trackpad flags

TP_FLAGS (0x02, offset 0)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	SEG_1	SEG_0	SWIPE RIGHT	SWIPE LEFT	SWIPE DOWN	SWIPE UP	TAP	TP ACTIVE

Bit definitions:

- Bit 7-6: Trackpad segment
  - 00: No trackpad segment event activation
  - 01: Segment 1 trackpad event activation (Y: 0 – 85)
  - 10: Segment 2 trackpad event activation (Y: 85 – 170)
  - 11: Segment 3 trackpad event activation (Y: 170 – 255)
- Bit 5: Swipe right
  - 0: No swipe event to report
  - 1: Swipe right event occurred
- Bit 4: Swipe left
  - 0: No swipe event to report
  - 1: Swipe left event occurred
- Bit 3: Swipe down
  - 0: No swipe event to report
  - 1: Swipe down event occurred
- Bit 2: Swipe up
  - 0: No swipe event to report
  - 1: Swipe up event occurred
- Bit 1: Tap
  - 0: No tap event to report
  - 1: Tap event occurred
- Bit 0: TP active
  - 0: Trackpad not actively in use
  - 1: Trackpad actively in use

4.4.2 X current position

X_CURR (0x03, offset 0)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	X_CURR							

Bit definitions:

- Bit 0 – 7:
  - 0 – 127: X current position in decimal

4.4.3 Y current position

Y_CURR (0x03, offset 1)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	Y_CURR							

Bit definitions:

- Bit 0 – 7:
  - 0 – 255: Y current position in decimal

4.5 0x04 Prox & Touch data

4.5.1 Prox channel 0

PROX_CHANNEL0 (0x04, offset 0)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	-	-	-	-	-	-	R
Name	-	-	-	-	-	-	-	CH0

Bit definitions:

- Bit 1: Channel 0 Prox
  - 0: No prox condition present on channel 0
  - 1: A prox condition is present on channel 0

4.5.2 Touch channels

TOUCH_CHANNELS (0x04, offset 1)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	-	CH6	CH5	CH4	CH3	CH2	CH1	CH0

Bit definitions:

- Bit 6: Channel 6 touch
  - 0: No touch on channel 6
  - 1: Touch present on channel 6
- Bit 5: Channel 5 touch
  - 0: No touch on channel 5
  - 1: Touch present on channel 5
- Bit 4: Channel 4 touch
  - 0: No touch on channel 4
  - 1: Touch present on channel 4
- Bit 3: Channel 3 touch
  - 0: No touch on channel 3
  - 1: Touch present on channel 3
- Bit 2: Channel 2 touch
  - 0: No touch on channel 2
  - 1: Touch present on channel 2
- Bit 1: Channel 1 touch
  - 0: No touch on channel 1
  - 1: Touch present on channel 1
- Bit 0: Channel 0 touch
  - 0: No touch on channel 0
  - 1: Touch present on channel

4.6 0x05 – 0x0B AC filtered channel count data

ACF_CHx								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	ACF Channel Low							
Bit Number	15	14	13	12	11	10	9	8
Data Access	R	R	R	R	R	R	R	R
Name	ACF Channel High							

Bit definitions:

- Bit 0-15: AC filtered or raw value counts

4.7 0x0C – 0x12 LTA data

LTA CHx								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	LTA Channel Low							
Bit Number	15	14	13	12	11	10	9	8
Data Access	R	R	R	R	R	R	R	R
Name	LTA Channel High							

Bit definitions:

- Bit 0-15: LTA filter value output

4.8 0x13 – 0x19 Deltas

Delta CHx								
Bit Number	7	6	5	4	3	2	1	0
Data Access	R	R	R	R	R	R	R	R
Name	Delta Channel Low							
Bit Number	15	14	13	12	11	10	9	8
Data Access	R	R	R	R	R	R	R	R
Name	Delta Channel High							

Bit definitions:

- Bit 0-15: Delta value of channel (LTA – ACF)

4.9 0x80 – 0x81 Prox settings

4.9.1 Prox settings 0

PROX_SETTINGS_0 (0x80, offset 0)								
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 ATI_OFF	ATI PARTIAL	ATI BAND	REDO ATI	DO RESEED	DEBUG ATI	INC STABL	FORCE HALT
Default	0	0	0	0	0	0	0	0
	0x00							

Bit definitions:

- Bit 7: Auto ATI
  - 0: Auto ATI on
  - 1: Auto ATI off
- Bit 6: ATI partial
  - 0: Normal ATI active
  - 1: Partial ATI active (Sensitivity multipliers are selected by the user and kept fixed)
- Bit 5: ATI band
  - 0: Normal ATI band
  - 1: Large ATI band
- Bit 4: Redo ATI
  - 0: None
  - 1: Redo an ATI
- Bit 3: Do reseed
  - 0: None
  - 1: Do a reseed operation
- Bit 2: Debug ATI
  - 0: No communication during ATI
  - 1: Communication during ATI allowed
- Bit 1: Increase stability
  - 0: Normal analogue settling time
  - 1: Increased analogue settling time for more stability
- Bit 0: Force halt
  - 0: Normal halting
  - 1: Force halt all channel LTA's

4.9.2 Prox settings 1

PROX_SETTINGS_1 (0x80, offset 1)								
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	COMMS WDT OFF	EVENT MODE	LTA FILTER		-	-	AC FILTER	
Default	0	0	0	1	0	0	0	1
	0x11							

Bit definitions:

- Bit 7: Communication watch dog timer off
  - 0: Communication watch dog timer enabled. Reset will occur if timeout occurs.
  - 1: Communication watch dog timer disabled. Reset will not occur upon timeout. It is not advised to disable the communication watch dog timer.

- Bit 6: Event mode:
  - 0: Streaming mode communication enabled
  - 1: Event mode communication enabled
- Bit 5-4: LTA filter beta selection
  - 00: LTA beta = 1/512
  - 01: LTA beta = 1/256
  - 10: LTA beta = 1/128
  - 11: LTA beta = 1/64
- Bit 1-0: AC filter beta selection
  - 00: AC filter off
  - 01: ACF beta = 1
  - 10: ACF beta = 2
  - 11: ACF beta = 3

4.9.3 Prox settings 2

PROX_SETTINGS_2 (0x81, offset 0)								
Bit Number	7	6	5	4	3	2	1	0
Data Access	-	-	R/W	-	R/W	R/W	R/W	R/W
Name	-	-	WAKE BOTH DIR	-	CLEAR TP FLAGS	NP_SEGMENT_RATE		
Default	0	0	0	0	0	0	1	1
	0x03							

Bit definitions:

- Bit 5: Wake both directions
  - 0: Normal activation in only one direction of count movement respective to LTA.
  - 1: Activation in both directions of count movement respective to LTA.
- Bit 4: Clear trackpad flags
  - 0: Trackpad flags stay set from last active trackpad event
  - 1: Trackpad flags are cleared after each communication window
- Bit 2-0: NP_SEGMENT_RATE
  - 0 - 7: Normal power segment rate = $2^{(NP\_SEGMENT\_RATE)}$
    - b'000 = 0: 1
    - b'001 = 1: 2
    - b'010 = 2: 4
    - b'011 = 3: 8
    - b'100 = 4: 16
    - b'101 = 5: 32
    - b'110 = 6: 64
    - b'111 = 7: 128

4.9.4 Prox settings 3

PROX_SETTINGS_3 (0x81, offset 1)								
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	ACK RESET	OFF MODE	PROJ BIAS	FLOAT CX	HALT CHARGE	CH0 DIST	XFER SLOW CH1-6	XFER SLOW CH0
Default	0	0	0	0	0	0	0	0
	0x00							