

# ICM-40607 Datasheet

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## 1 INTRODUCTION

### 1.1 PURPOSE AND SCOPE

This document is a product specification, providing a description, specifications, and design related information on the ICM-40607 Single-Interface MotionTracking device. The device is housed in a small 2.5x3x0.91 mm 14-pin LGA package.

### 1.2 PRODUCT OVERVIEW

The ICM-40607 is a 6-axis MotionTracking device that combines a 3-axis gyroscope, and a 3-axis accelerometer in a small 2.5x3x0.91 mm (14-pin LGA) package. It also features a 2K-byte FIFO that can lower the traffic on the serial bus interface, and reduce power consumption by allowing the system processor to burst read sensor data and then go into a low-power mode. ICM-40607, with its 6-axis integration, enables manufacturers to eliminate the costly and complex selection, qualification, and system level integration of discrete devices, guaranteeing optimal motion performance for consumers.

The gyroscope supports eight independently programmable full-scale range settings from  $\pm 15.625$ dps to  $\pm 2000$ dps, and the accelerometer supports four independently programmable full-scale range settings from  $\pm 2$ g to  $\pm 16$ g.

Other industry-leading features include on-chip 16-bit ADCs, programmable digital filters, an embedded temperature sensor, and programmable interrupts. The device features I<sup>2</sup>C and SPI serial interfaces, a VDD operating range of 1.71 V to 3.6 V, and a separate VDDIO operating range of 1.71V to 3.6V.

The host interface can be configured to support I<sup>2</sup>C slave or SPI slave modes. The I<sup>2</sup>C interface supports speeds up to 1 MHz, and the SPI interface supports speeds up to 24 MHz.

By leveraging its patented and volume-proven CMOS-MEMS fabrication platform, which integrates MEMS wafers with companion CMOS electronics through wafer-level bonding, InvenSense has driven the package size down to a footprint and thickness of 2.5x3x0.91 mm (14-pin LGA), to provide a very small yet high performance low cost package. The device provides high robustness by supporting 20,000g shock reliability.

### 1.3 APPLICATIONS

- Smartphones and Tablets
- Head Mounted Displays
- Wearable Sensors



## 2 FEATURES

### 2.1 GYROSCOPE FEATURES

The triple-axis MEMS gyroscope in the ICM-40607 includes a wide range of features:

- Digital-output X-, Y-, and Z-axis angular rate sensors (gyroscopes) with independently programmable full-scale range of  $\pm 15.625$ ,  $\pm 31.25$ ,  $\pm 62.5$ ,  $\pm 125$ ,  $\pm 250$ ,  $\pm 500$ ,  $\pm 1000$ , and  $\pm 2000$  degrees/sec
- Low Noise (LN) power mode support
- Digitally-programmable low-pass filters
- Factory calibrated sensitivity scale factor
- Self-test

### 2.2 ACCELEROMETER FEATURES

The triple-axis MEMS accelerometer in ICM-40607 includes a wide range of features:

- Digital-output X-, Y-, and Z-axis accelerometer with independently programmable full-scale range of  $\pm 2g$ ,  $\pm 4g$ ,  $\pm 8g$  and  $\pm 16g$
- Low Noise (LN) and Low Power (LP) power modes support
- User-programmable interrupts
- Wake-on-motion interrupt for low power operation of applications processor
- Self-test

### 2.3 MOTION FEATURES

ICM-40607 includes the following motion features, also known as APEX (Advanced Pedometer and Event Detection – neXt gen)

- Pedometer: Tracks Step Count, also issues Step Detect interrupt
- Tilt Detection: Issues an interrupt when the Tilt angle exceeds  $35^\circ$  for more than a programmable time
- Raise to Wake/Sleep: Gesture detection for wake and sleep events. Interrupt is issued when either of these two events are detected.
- Tap Detection: Issues an interrupt when a tap is detected, along with the tap count
- Wake on Motion: Detects motion when accelerometer data exceeds a programmable threshold.
- Significant Motion Detection: Detects Significant Motion if Wake on Motion events are detected during a programmable time window

### 2.4 ADDITIONAL FEATURES

ICM-40607 includes the following additional features:

- 2K byte FIFO buffer enables the applications processor to read the data in bursts
- User-programmable digital filters for gyroscope, accelerometer, and temperature sensor
- Wake on Motion: Detects motion when accelerometer data exceeds a programmable threshold
- 1 MHz I<sup>2</sup>C / 24 MHz SPI slave host interface
- Digital-output temperature sensor
- Smallest and thinnest LGA package for portable devices: 2.5x3x0.91 mm (14-pin LGA)
- 20,000 g shock tolerant
- MEMS structure hermetically sealed and bonded at wafer level
- RoHS and Green compliant

### 3 ELECTRICAL CHARACTERISTICS

#### 3.1 GYROSCOPE SPECIFICATIONS

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T<sub>A</sub>=25°C, unless otherwise noted.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
<b>GYROSCOPE SENSITIVITY</b>						
Full-Scale Range	GYRO_FS_SEL=0		±2000		°/s	2
	GYRO_FS_SEL =1		±1000		°/s	2
	GYRO_FS_SEL =2		±500		°/s	2
	GYRO_FS_SEL =3		±250		°/s	2
	GYRO_FS_SEL =4		±125		°/s	2
	GYRO_FS_SEL =5		±62.5		°/s	2
	GYRO_FS_SEL =6		±31.25		°/s	2
	GYRO_FS_SEL =7		±15.625		°/s	2
Gyroscope ADC Word Length			16		bits	2
Sensitivity Scale Factor	GYRO_FS_SEL=0		16.4		LSB/(°/s)	2
	GYRO_FS_SEL =1		32.8		LSB/(°/s)	2
	GYRO_FS_SEL =2		65.5		LSB/(°/s)	2
	GYRO_FS_SEL =3		131		LSB/(°/s)	2
	GYRO_FS_SEL =4		262		LSB/(°/s)	2
	GYRO_FS_SEL =5		524.3		LSB/(°/s)	2
	GYRO_FS_SEL =6		1048.6		LSB/(°/s)	2
	GYRO_FS_SEL =7		2097.2		LSB/(°/s)	2
Sensitivity Scale Factor Initial Tolerance	25°C		±1	+2	%	1, 5
Sensitivity Scale Factor Variation Over Temperature	-40°C to +85°C	-0.034	±0.01	+0.034	%/°C	3, 5
Nonlinearity	Best fit straight line; 25°C		±0.2		%	3
Cross-Axis Sensitivity		-3	±2	+3	%	3, 5
<b>ZERO-RATE OUTPUT (ZRO)</b>						
Initial ZRO Tolerance	Board-level, 25°C	-20	±5	+20	°/s	3, 5
ZRO Variation vs. Temperature	-40°C to +85°C	-0.05	±0.03	+0.05	°/s/°C	3, 5
<b>OTHER PARAMETERS</b>						
Rate Noise Spectral Density	@ 10 Hz		0.007	0.014	°/s/√Hz	1, 5
Total RMS Noise	Bandwidth = 100 Hz		0.07	0.14	°/s-rms	4, 5
Gyroscope Mechanical Frequencies		25	27	29	KHz	1
Low Pass Filter Response	ODR < 1kHz	5		500	Hz	2
	ODR ≥ 1kHz	5		995	Hz	2
Gyroscope Start-Up Time	Time from gyro enable to gyro drive ready		30	45	ms	3, 5
Output Data Rate		12.5		8000	Hz	2

**Table 1. Gyroscope Specifications**

**Notes:**

1. Tested in production.
2. Guaranteed by design.
3. Derived from validation or characterization of parts, not guaranteed in production.
4. Calculated from Rate Noise Spectral Density.
5. MIN?MAX or MAX specs are derived from characterization data based 3σ calculation.

### 3.2 ACCELEROMETER SPECIFICATIONS

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T<sub>A</sub>=25°C, unless otherwise noted.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
<b>ACCELEROMETER SENSITIVITY</b>						
Full-Scale Range	ACCEL_FS_SEL =0		±16		g	2
	ACCEL_FS_SEL =1		±8		g	2
	ACCEL_FS_SEL =2		±4		g	2
	ACCEL_FS_SEL =3		±2		g	2
ADC Word Length	Output in two's complement format		16		bits	2
Sensitivity Scale Factor	ACCEL_FS_SEL =0		2,048		LSB/g	2
	ACCEL_FS_SEL =1		4,096		LSB/g	2
	ACCEL_FS_SEL =2		8,192		LSB/g	2
	ACCEL_FS_SEL =3		16,384		LSB/g	2
Sensitivity Scale Factor Initial Tolerance	Component-level	-2	±1	+2	%	1, 5
Sensitivity Change vs. Temperature	-40°C to +85°C	-0.03	±0.01	+0.03	%/°C	3, 5
Nonlinearity	Best Fit Straight Line, ±2g		±0.2		%	3
Cross-Axis Sensitivity		-4	±2	+4	%	3, 5
<b>ZERO-G OUTPUT</b>						
Initial Tolerance	Board-level, all axes	±120	±60	±120	mg	3, 5
Zero-G Level Change vs. Temperature	-40°C to +85°C	-1	±0.1	+1	mg/°C	3, 5
<b>OTHER PARAMETERS</b>						
Power Spectral Density	@ 10 Hz		120	160	μg/√Hz	1, 5
RMS Noise	Bandwidth = 100 Hz		1.10	1.60	mg-rms	4, 5
Low-Pass Filter Response	ODR < 1kHz	5		500	Hz	2
	ODR ≥ 1kHz	5		995	Hz	2
Accelerometer Startup Time	From sleep mode to valid data		10	20	ms	3, 5
Output Data Rate		1.5625		8000	Hz	2

Table 2. Accelerometer Specifications

**Notes:**

1. Tested in production.
2. Guaranteed by design.
3. Derived from validation or characterization of parts, not guaranteed in production.
4. Calculated from Power Spectral Density.
5. MIN/MAX or MAX specs are derived from characterization data based 3σ calculation.

### 3.3 ELECTRICAL SPECIFICATIONS

#### 3.3.1 D.C. Electrical Characteristics

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T<sub>A</sub>=25°C, unless otherwise noted.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
<b>SUPPLY VOLTAGES</b>						
VDD		1.71	1.8	3.6	V	1
VDDIO		1.71	1.8	3.6	V	1
<b>SUPPLY CURRENTS</b>						
Low-Noise Mode	6-Axis Gyroscope + Accelerometer		0.65	0.70	mA	2, 3
	3-Axis Accelerometer		0.25	0.30	mA	2, 3
	3-Axis Gyroscope		0.52	0.60	mA	2, 3
Accelerometer Low -Power Mode (Gyroscope disabled)	200Hz ODR, 1x averaging		46	91	μA	2, 3
Full-Chip Sleep Mode	At 25°C		7.5	20	μA	2, 3
<b>TEMPERATURE RANGE</b>						
Specified Temperature Range	Performance parameters are not applicable beyond Specified Temperature Range	-40		+85	°C	1

**Table 3. D.C. Electrical Characteristics**

**Notes:**

1. Guaranteed by design.
2. Derived from validation or characterization of parts, not guaranteed in production.
3. MIN/MAX or MAX specs are derived from characterization data based on calculation.

### 3.3.2 A.C. Electrical Characteristics

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T<sub>A</sub>=25°C, unless otherwise noted.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
SUPPLIES						
Supply Ramp Time	Monotonic ramp. Ramp rate is 10% to 90% of the final value	0.01		3	ms	1
Power Supply Noise	Up to 10kHz		10	50	mV peak-peak	1
TEMPERATURE SENSOR						
Operating Range	Ambient	-40		85	°C	1
25°C Output			0		LSB	3
ADC Resolution			16		bits	2
ODR	With Filter	25		8000	Hz	2
Room Temperature Offset	25°C	-5		5	°C	3
Stabilization Time				14000	μs	2
Sensitivity	Untrimmed		132.48		LSB/°C	1
Sensitivity for FIFO data			2.07		LSB/°C	1
POWER-ON RESET						
Start-up time for register read/write	From power-up			1	ms	1
I²C ADDRESS						
I²C ADDRESS	AP_AD0 = 0 AP_AD0 = 1		1 010 00 1 010 001			
DIGITAL INPUTS (FSYNC, SCLK, SDI, CS)						
V <sub>IH</sub> , High Level Input Voltage		0.7*VDDIO			V	1
V <sub>IL</sub> , Low Level Input Voltage				0.3*VDDIO	V	
C <sub>i</sub> , Input Capacitance			< 10		pF	
Input Leakage Current			100		nA	
DIGITAL OUTPUT (SDO, INT1, INT2)						
V <sub>OH</sub> , High Level Output Voltage	R <sub>LOAD</sub> =1 MΩ;	0.9*VDDIO			V	1
V <sub>OL1</sub> , LOW-Level Output Voltage	R <sub>LOAD</sub> =1 MΩ;			0.1*VDDIO	V	
V <sub>OLINT</sub> , INT Low-Level Output Voltage	OPEN=1, 0.3 mA sink Current			0.1	V	
Output Leakage Current	OPEN=1		100		nA	
t <sub>INT</sub> , INT Pulse Width	int_tpulse_duration=0.1 (100us, 8us) ;	8		100	μs	
I²C I/C (SCL, SDA)						
V <sub>IL</sub> , LOW-Level Input Voltage		-0.5 V		0.3*VDDIO	V	1
V <sub>IH</sub> , HIGH-Level Input Voltage		0.7*VDDIO		VDDIO + 0.5 V	V	
V <sub>HYS</sub> , Hysteresis			0.1*VDDIO		V	
V <sub>OL</sub> , LOW-Level Output Voltage	3 mA sink current	0		0.4	V	
I <sub>OL</sub> , LOW-Level Output Current	V <sub>OL</sub> =0.4 V V <sub>OL</sub> =0.6 V		3 6		mA mA	
Output Leakage Current			100		nA	
t <sub>ofr</sub> , Output Fall Time from V <sub>IHmax</sub> to V <sub>ILmax</sub>	C <sub>b</sub> bus capacitance in pf	20+0.1C <sub>b</sub>		300	ns	
INTERNAL CLOCK SOURCE						
Clock Frequency Initial Tolerance	CLKSEL='2b00 or gyro inactive; 25°C	-3		+3	%	1
	CLK_SEL='2b01 and gyro active; 25°C	-1		+1	%	1
Frequency Variation over Temperature	CLK_SEL='2b00 or gyro inactive; -40°C to +85°C			±3	%	1
	CLK_SEL='2b01 and gyro active; -40°C to +85°C			±2	%	1

**Table 4. A.C. Electrical Characteristics**

**Notes:**

1. Expected results based on design, will be updated after characterization. Not guaranteed in production.
2. Guaranteed by design.
3. To be Production tested.

### 3.4 I<sup>2</sup>C TIMING CHARACTERIZATION

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T<sub>A</sub>=25°C, unless otherwise noted.

Parameters	Conditions	Min	Typical	Max	Units	Notes
<b>I<sup>2</sup>C TIMING</b>						
f <sub>SCL</sub> , SCL Clock Frequency				1	MHz	1
t <sub>HD,STA</sub> , (Repeated) START Condition Hold Time		0.26			μs	1
t <sub>LOW</sub> , SCL Low Period		0.5			μs	1
t <sub>HIGH</sub> , SCL High Period		0.26			μs	1
t <sub>SU,STA</sub> , Repeated START Condition Setup Time		0.26			μs	1
t <sub>HD,DAT</sub> , SDA Data Hold Time		0			μs	1
t <sub>SU,DAT</sub> , SDA Data Setup Time		50			ns	1
t <sub>r</sub> , SDA and SCL Rise Time	C <sub>b</sub> bus cap. from 10 to 400 pF			120	ns	1
t <sub>f</sub> , SDA and SCL Fall Time	C <sub>b</sub> bus cap. from 10 to 400 pF			120	ns	1
t <sub>SU,STO</sub> , STOP Condition Setup Time		0.5			μs	1
t <sub>BUF</sub> , Bus Free Time Between STOP and START Condition		0.5			μs	1
C <sub>b</sub> , Capacitive Load for each Bus Line			< 400		pF	1
t <sub>VD,DAT</sub> , Data Valid Time				0.45	μs	1
t <sub>VD,ACK</sub> , Data Valid Acknowledge Time				0.45	μs	1

Table 5. I<sup>2</sup>C Timing Characteristics

#### Notes:

- Based on characterization of 5 parts over temperature and voltage as mounted on evaluation board or in sockets

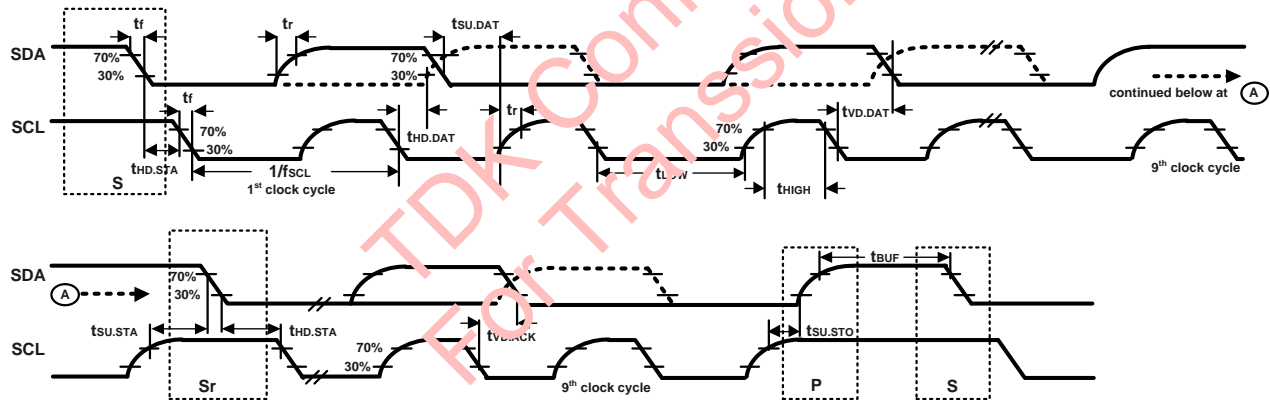


Figure 1. I<sup>2</sup>C Bus Timing Diagram

### 3.5 SPI TIMING CHARACTERIZATION – 4-WIRE SPI MODE

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T<sub>A</sub>=25°C, unless otherwise noted.

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
<b>SPI TIMING</b>						
f <sub>SPC</sub> , SCLK Clock Frequency	Default			24	MHz	1
t <sub>LOW</sub> , SCLK Low Period		24.5			ns	1
t <sub>HIGH</sub> , SCLK High Period		24.5			ns	1
t <sub>SU,CS</sub> , CS Setup Time		39			ns	1
t <sub>HD,CS</sub> , CS Hold Time		18			ns	1
t <sub>SU,SDI</sub> , SDI Setup Time		13			ns	1
t <sub>HD,SDI</sub> , SDI Hold Time		8			ns	1
t <sub>VD,SDO</sub> , SDO Valid Time	C <sub>load</sub> = 20 pF			21.5	ns	1
t <sub>HD,SDO</sub> , SDO Hold Time	C <sub>load</sub> = 20 pF	9.5			ns	1
t <sub>DIS,SDO</sub> , SDO Output Disable Time				28	ns	1

Table 6. SPI Timing Characteristics (24-MHz Operation)

**Notes:**

- Based on characterization of 5 parts over temperature and voltage as mounted on evaluation board or in sockets

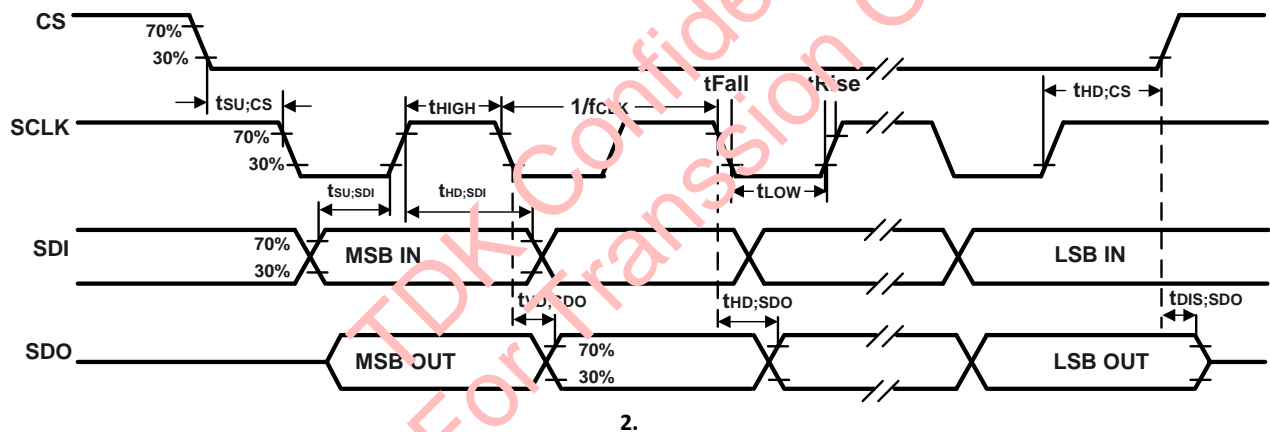


Figure 2. 4-Wire SPI Mode-3 Bus Timing Diagram

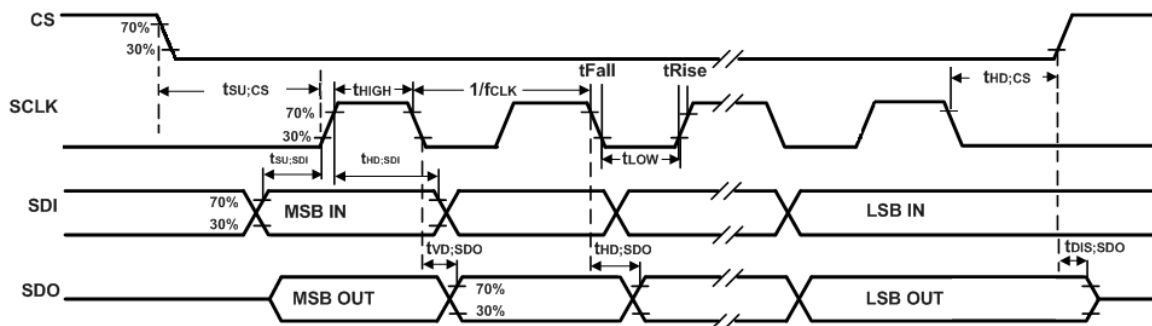


Figure 3. 4-Wire SPI Mode-0 Bus Timing Diagram

### 3.6 SPI TIMING CHARACTERIZATION – 3-WIRE SPI MODE

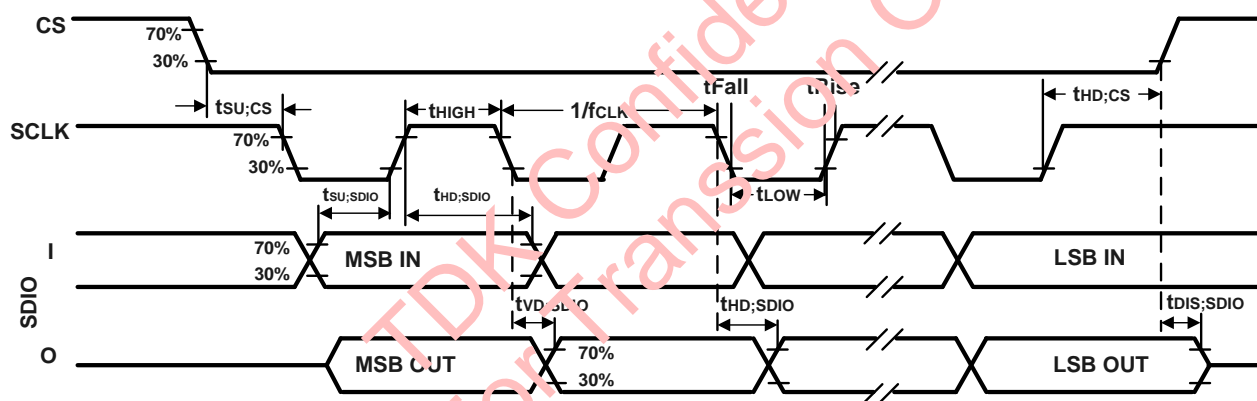
Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T<sub>A</sub>=25°C, unless otherwise noted.

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
<b>SPI TIMING</b>						
f <sub>SPC</sub> , SCLK Clock Frequency	Default			24	MHz	1
t <sub>LOW</sub> , SCLK Low Period		24.5			ns	1
t <sub>HIGH</sub> , SCLK High Period		24.5			ns	1
t <sub>SU,CS</sub> , CS Setup Time		39			ns	1
t <sub>HD,CS</sub> , CS Hold Time		5			ns	1
t <sub>SU,SDIO</sub> , SDIO Input Setup Time		13			ns	1
t <sub>HD,SDIO</sub> , SDIO Input Hold Time		8			ns	1
t <sub>VD,SDIO</sub> , SDIO Output Valid Time	C <sub>load</sub> = 20 pF			18.5	ns	1
t <sub>HD,SDIO</sub> , SDIO Output Hold Time	C <sub>load</sub> = 20 pF	9.5			ns	1
t <sub>DIS,SDIO</sub> , SDIO Output Disable Time				28	ns	1

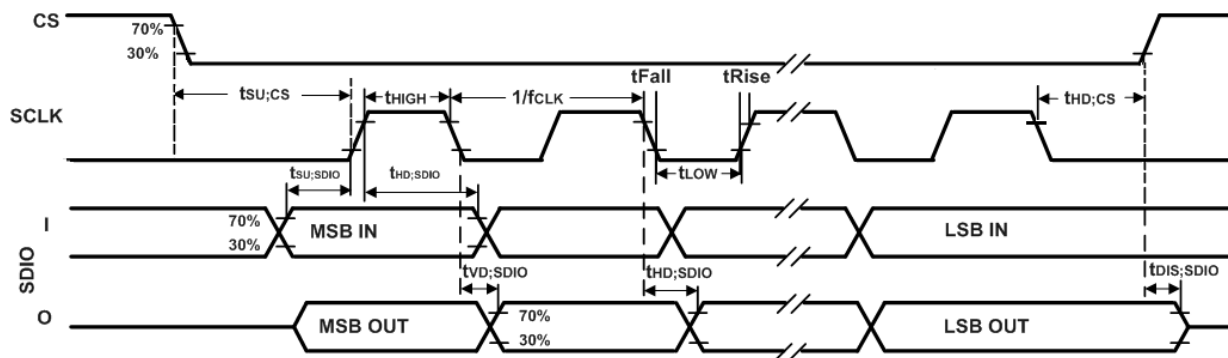
**Table 7. SPI Timing Characteristics (24-MHz Operation)**

**Notes:**

- Based on characterization of 5 parts over temperature and voltage as mounted on evaluation board or in sockets.



**Figure 4. 3-Wire Mode-3 SPI Bus Timing Diagram**



**Figure 5. 3-Wire Mode-0 SPI Bus Timing Diagram**



### 3.7 ABSOLUTE MAXIMUM RATINGS

Stress above those listed as “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to the absolute maximum ratings conditions for extended periods may affect device reliability.

Parameter	Rating
Supply Voltage, VDD	-0.5 V to +4 V
Supply Voltage, VDDIO	-0.5 V to +4 V
Input Voltage Level (SCL, SDA)	-0.5 V to VDD + 0.5 V
Acceleration (Any Axis, unpowered)	20,000g for 0.2 ms
Operating Temperature Range	-40°C to +85°C
Storage Temperature Range	-40°C to +125°C
Electrostatic Discharge (ESD) Protection	2 kV (HBM); 200 V (MM)
Latch-up	JEDEC Class I (2), 125°C ±100 mA

**Table 8. Absolute Maximum Ratings**

## 4 APPLICATIONS INFORMATION

### 4.1 PIN OUT DIAGRAM AND SIGNAL DESCRIPTION

Pin Number	Pin Name	Pin Description
1	AP_SDO / AP_AD0	AP_SDO: AP SPI serial data output (4-wire mode); AP_AD0: AP I <sup>2</sup> C slave address LSB
2	RESV	No Connect or Connect to GND
3	RESV	No Connect or Connect to GND
4	INT1 / INT	INT1: Interrupt 1 (Note: INT1 can be push-pull or open drain) INT: All interrupts mapped to pin 4
5	VDDIO	IO power supply voltage
6	GND	Power supply ground
7	RESV	Connect to GND
8	VDD	Power supply voltage
9	INT2	INT2: Interrupt 2 (Note: INT2 can be push-pull or open drain)
10	RESV	No Connect or Connect to GND
11	RESV	No Connect or Connect to GND
12	AP_CS	AP SPI Chip select (AP SPI interface); Connect to VDDIO if using AP I <sup>2</sup> C interface
13	AP_SCL / AP_SCLK	AP_SCL: AP I <sup>2</sup> C serial clock; AP_SCLK: AP SPI serial clock
14	AP_SDA / AP_SDIO / AP_SDI	AP_SDA: AP I <sup>2</sup> C serial data; AP_SDIO: AP SPI serial data I/O (3-wire mode); AP_SDI: AP SPI serial data input (4-wire mode)

Table 9. Signal Descriptions

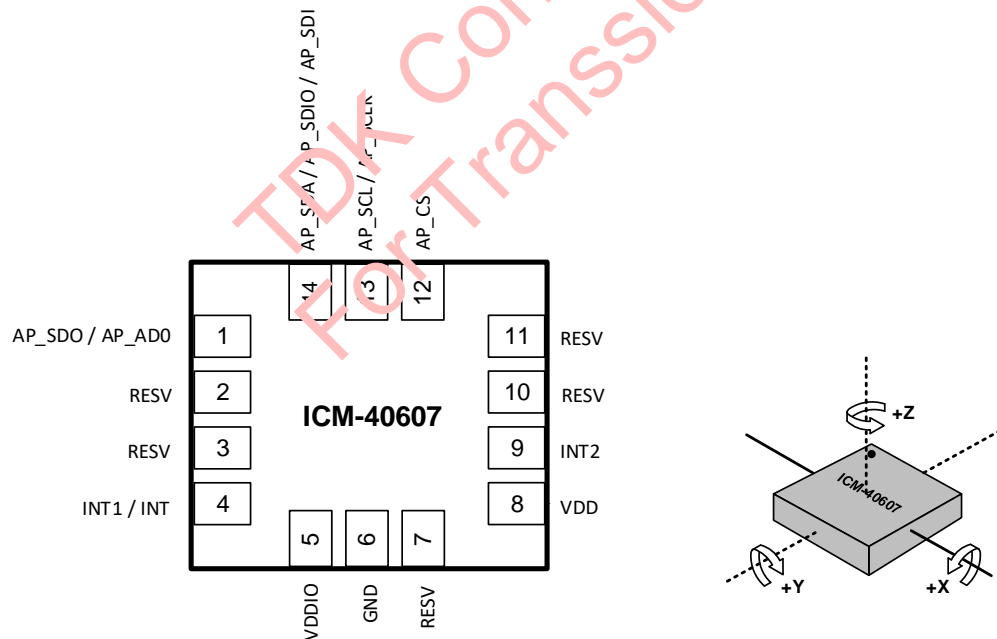
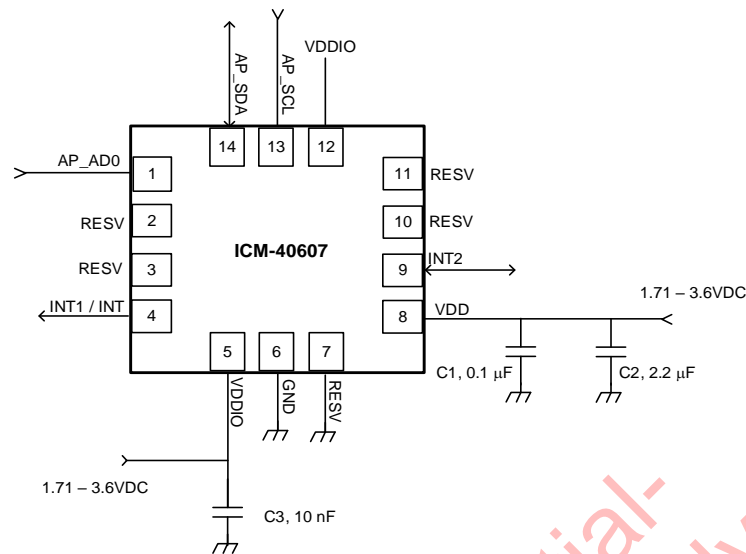


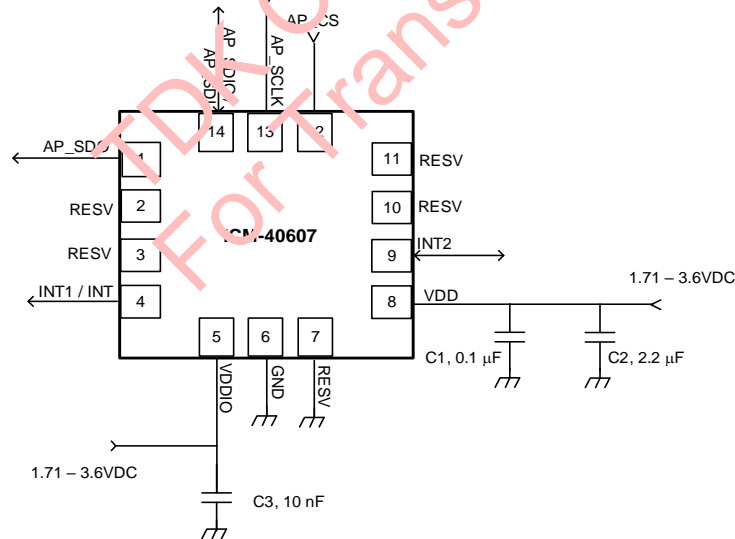
Figure 6. Pin Out Diagram for ICM-40607 2.5x3.0x0.91 mm LGA

## 4.2 TYPICAL OPERATING CIRCUIT



**Figure 7. ICM-40607 Application Schematic (I<sup>2</sup>C Interface to Host)**

Note: I<sup>2</sup>C lines are open drain and pull-up resistors (e.g. 10 kΩ) are required.



**Figure 8. ICM-40607 Application Schematic (SPI Interface to Host)**

### 4.3 BILL OF MATERIALS FOR EXTERNAL COMPONENTS

Component	Label	Specification	Quantity
VDD Bypass Capacitors	C1	X7R, 0.1 $\mu$ F $\pm$ 10%	1
	C2	X7R, 2.2 $\mu$ F $\pm$ 10%	1
VDDIO Bypass Capacitor	C3	X7R, 10nF $\pm$ 10%	1

**Table 10. Bill of Materials**

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#### 4.4 SYSTEM BLOCK DIAGRAM

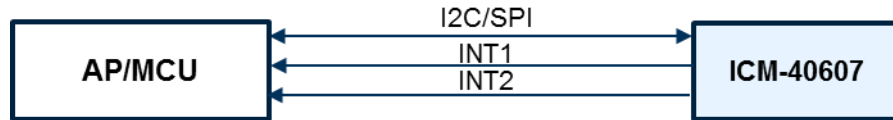


Figure 9. ICM-40607 System Block Diagram

Note: The above block diagram is an example. Please refer to the pin-out (section 4.1) for other configuration options.

#### 4.5 OVERVIEW

The ICM-40607 is comprised of the following key blocks and functions:

- Three-axis MEMS rate gyroscope sensor with 16-bit ADCs and signal conditioning
- Three-axis MEMS accelerometer sensor with 16-bit ADCs and signal conditioning
- I<sup>2</sup>C and SPI serial communications interfaces to Host
- Self-Test
- Clocking
- Sensor Data Registers
- FIFO
- Interrupts
- Digital-Output Temperature Sensor
- Bias and LDOs
- Charge Pump
- Standard Power Modes

#### 4.6 THREE-AXIS MEMS GYROSCOPE WITH 16 BIT ADCS AND SIGNAL CONDITIONING

The ICM-40607 includes a vibratory MEMS rate gyroscope, which detects rotation about the X-, Y-, and Z- Axes. When the gyroscope is rotated about any of the sense axes, the Coriolis Effect causes a vibration that is detected by a capacitive pickoff. The resulting signal is amplified, demodulated, and filtered to produce a voltage that is proportional to the angular rate. This voltage is digitized using on-chip Analog-to-Digital Converters (ADCs) to sample each axis. The full-scale range of the gyro sensors may be digitally programmed to  $\pm 15.625$ ,  $\pm 31.25$ ,  $\pm 62.5$ ,  $\pm 125$ ,  $\pm 250$ ,  $\pm 500$ ,  $\pm 1000$ , and  $\pm 2000$  degrees per second (dps).

#### 4.7 THREE-AXIS MEMS ACCELEROMETER WITH 16-BIT ADCS AND SIGNAL CONDITIONING

The ICM-40607 includes a 3-Axis MEMS accelerometer. Acceleration along a particular axis induces displacement of a proof mass in the MEMS structure, and capacitive sensors detect the displacement. The ICM-40607 architecture reduces the accelerometers' susceptibility to fabrication variations as well as to thermal drift. When the device is placed on a flat surface, it will measure 0g on the X- and Y-axes and +1g on the Z-axis. The accelerometers' scale factor is calibrated at the factory and is nominally independent of supply voltage. The full-scale range of the digital output can be adjusted to  $\pm 2g$ ,  $\pm 4g$ ,  $\pm 8g$  and  $\pm 16g$ .

#### 4.8 I<sup>2</sup>C AND SPI HOST INTERFACE

The ICM-40607 communicates to the application processor using an I<sup>2</sup>C, or SPI serial interface. The ICM-40607 always acts as a slave when communicating to the application processor.

#### 4.9 SELF-TEST

Self-test allows for the testing of the mechanical and electrical portions of the sensors. The self-test for each measurement axis can be activated by means of the gyroscope and accelerometer self-test registers.

When the self-test is activated, the electronics cause the sensors to be actuated and produce an output signal. The output signal is used to observe the self-test response.

The self-test response is defined as follows:

Self-test response = Sensor output with self-test enabled – Sensor output with self-test disabled

When the value of the self-test response is within the specified min/max limits of the product specification, the part has passed self-test. When the self-test response exceeds the min/max values, the part is deemed to have failed self-test.

## 4.10 CLOCKING

The ICM-40607 has a flexible clocking scheme, allowing the following internal clock sources to be used for the internal synchronous circuitry. This synchronous circuitry includes the signal conditioning and ADCs, and various control circuits and registers.

- a) An internal relaxation oscillator
- b) Auto-select between internal relaxation oscillator and gyroscope MEMS oscillator to use the best available source

The only setting supporting specified performance in all modes is option b). It is recommended that option b) be used when using internal clock source.

## 4.11 SENSOR DATA REGISTERS

The sensor data registers contain the latest gyroscope, accelerometer, and temperature measurement data. They are read-only registers, and are accessed via the serial interface. Data from these registers may be read anytime.

## 4.12 INTERRUPTS

Interrupt functionality is configured via the Interrupt Configuration register. Items that are configurable include the interrupt pins configuration, the interrupt latching and clearing method, and triggers for the interrupt. Items that can trigger an interrupt are (1) Clock generator locked to new reference oscillator (used when switching clock sources); (2) new data is available to be read (from the FIFO and Data registers); (3) accelerometer event interrupts; (4) FIFO watermark; (5) FIFO overflow. The interrupt status can be read from the Interrupt Status register.

## 4.13 DIGITAL-OUTPUT TEMPERATURE SENSOR

An on-chip temperature sensor and ADC are used to measure the ICM-40607 die temperature. The readings from the ADC can be read from the FIFO or the Sensor Data registers.

Temperature data value from the sensor data registers can be converted to degrees centigrade by using the following formula:

$$\text{Temperature in Degrees Centigrade} = (\text{TEMP\_DATA} / 132.48) + 25$$

Temperature data stored in FIFO is an 8-bit quantity, FIFO\_TEMP\_DATA. It can be converted to degrees centigrade by using the following formula:

$$\text{Temperature in Degrees Centigrade} = (\text{FIFO\_TEMP\_DATA} / 2.07) + 25$$

## 4.14 BIAS AND LDOs

The bias and LDO section generates the internal supply and the reference voltages and currents required by the ICM-40607.

## 4.15 CHARGE PUMP

An on-chip charge pump generates the high voltage required for the MEMS oscillator.

## 4.16 STANDARD POWER MODES

The following table lists the user-accessible power modes for ICM-40607.

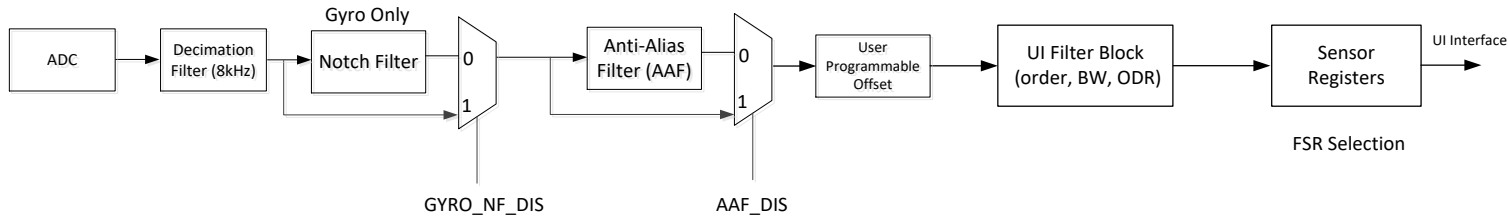
Mode	Name	Gyro	Accel
1	Sleep Mode	Off	Off
2	Standby Mode	Drive On	Off
3	Accelerometer Low-Power Mode	Off	Duty-Cycled
4	Accelerometer Low-Noise Mode	Off	On
5	Gyroscope Low-Noise Mode	On	Off
6	6-Axis Low-Noise Mode	On	On

**Table 11. Standard Power Modes for ICM-40607**

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## 5 SIGNAL PATH

The following figure shows a block diagram of the signal path for ICM-40607.



**Figure 10. ICM-40607 Signal Path**

The signal path starts with ADCs for the gyroscope and accelerometer. Other components of the signal path are described below in further detail.

### 5.1 SUMMARY OF PARAMETERS USED TO CONFIGURE THE SIGNAL PATH

The following table shows the parameters that can control the signal path.

Parameter Name	Description
GYRO_AAF_DIS	Disables the Gyroscope Anti Alias Filter (AAF)
GYRO_AAF_DELT GYRO_AAF_DELTSQR GYRO_AAF_BITSHIFT	Three parameters required to program the gyroscope AAF. This is a 2 <sup>nd</sup> order filter with programmable low pass filter. This is a user programmable filter which can be used to select the desired BW. This filter allows trading off RMS noise vs. latency for a given ODR.
ACCEL_AAF_DIS	Disables the Accelerometer Anti Alias Filter
ACCEL_AAF_DELT ACCEL_AAF_DELTSQR ACCEL_AAF_BITSHIFT	Three parameters required to program the accelerometer AAF. This is a 2 <sup>nd</sup> order filter with programmable low pass filter. This is a user programmable filter which can be used to select the desired BW. This filter allows trading off RMS noise vs. latency for a given ODR.
GYRO_NF_DIS	Disables the gyro Notch Filter
GYRO_X/Y/Z_NF_COSWZ GYRO_X/Y/Z_NF_COSWZ_SEL	Factory trimmed parameters, designed to position a Notch at or near the sense peak frequency of Gyro. This allows the user to suppress only sense peak contribution to noise, while still maintaining a low latency high BW/ODR interface from the Sensor. This filter is available only in Gyro, and the parameters for X, Y, and Z are chosen independently.
GYRO_NF_BW_SEL	Factory trimmed parameter to cancel noise created by sense peak from Gyro. This parameter is common to all three axes

### 5.2 NOTCH FILTER

The Notch Filter is supported only for the gyroscope signal path. The following steps can be used to program the notch filter. Note that the notch filter is specific to each axis in the gyroscope, so the X, Y and Z axis can be programmed independently.

#### Frequency of Notch Filter (each axis)

To operate the Notch filter, two parameters NF\_COSWZ, and NF\_COSWZ\_SEL must be programmed for each gyroscope axis.

Parameters NF\_COSWZ are defined for each axis of the gyroscope as GYRO\_X\_NF\_COSWZ (register bank 1, register 0x0Fh & register 0x12h), GYRO\_Y\_NF\_COSWZ (register bank 1, register 0x10h & register 0x12h), GYRO\_Z\_NF\_COSWZ (register bank 1, register 0x11h & register 0x12h). Note that the parameters have 9-bit values across two different registers.



Parameters NF\_COSWZ\_SEL are defined for each axis of the gyroscope as GYRO\_X\_NF\_COSWZ\_SEL (register bank 1, register 0x12h, bit 3), GYRO\_Y\_NF\_COSWZ\_SEL (register bank 1, register 0x12h, bit 4), GYRO\_Z\_NF\_COSWZ\_SEL (register bank 1, register 0x12h, bit 5).

Each value must be calculated using the steps described below, and programmed into the corresponding register locations mentioned above.

$f_{desired}$  is the desired frequency of the Notch Filter in kHz. The lower bound for  $f_{desired}$  is 1kHz, and the upper bound is 3kHz. Operating the notch filter outside this range is not supported.

Step1:  $COSWZ = \cos(2 * \pi * f_{desired} / 8)$

Step2:

```

If abs(COSWZ) ≤ 0.875
    NF_COSWZ = round[COSWZ*256]
    NF_COSWZ_SEL = 0
else
    NF_COSWZ_SEL = 1
    if COSWZ > 0.875
        NF_COSWZ = round [8*(1-COSWZ)*256]
    else if COSWZ < -0.875
        NF_COSWZ = round [-8*(1+COSWZ)*256]
    end
End
    
```

### Bandwidth of Notch Filter (common to all axes)

The notch filter allows the user to control the width of the notch from eight possible values using a 3-bit parameter GYRO\_NF\_BW\_SEL in register bank 1, register 0x13h, bits 6:4. This parameter is common to all three axes.

GYRO_NF_BW_SEL	Notch Filter Bandwidth (Hz)
0	362
1	170
2	83
3	41
4	21
5	11
6	5
7	3

The notch filter can be selected or bypassed by using the parameter GYRO\_NF\_DIS in register bank 1, register 0x0Bh, bit 0 as shown below.

GYRO_NF_DIS	Function
0	Enable notch filter
1	Disable notch filter

### 5.3 ANTI-ALIAS FILTER

Anti-alias filters for gyroscope and accelerometer can be independently programmed to have bandwidths ranging from 10 Hz to 995 Hz. To program the anti-alias filter for a required bandwidth, use the table below to map the bandwidth to register values as shown:

- Register bank 2, register 0x03h, bits 6:1, ACCEL\_AAF\_DELT: Code from 1 to 63 that allows programming the bandwidth for accelerometer anti-alias filter
- Register bank 2, register 0x04h, bits 7:0 and Bank 2, register 0x05h, bits 3:0, ACCEL\_AAF\_DELTSQR: Square of the delt value for accelerometer
- Register bank 2, register 0x05h, bits 7:4, ACCEL\_AAF\_BITSHIFT: Bitshift value for accelerometer used in hardware implementation
- Register bank 1, register 0x0Ch, bits 5:0, GYRO\_AAF\_DELT: Code from 1 to 63 that allows programming the bandwidth for gyroscope anti-alias filter
- Register bank 1, register 0x0Dh, bits 7:0 and Bank 1, register 0x0Eh, bits 3:0, GYRO\_AAF\_DELTSQR: Square of the delt value for gyroscope
- Register bank 1, register 0x0Eh, bits 7:4, GYRO\_AAF\_BITSHIFT: Bitshift value for gyroscope used in hardware implementation

3dB Bandwidth (Hz)	ACCEL_AAF_DELT; GYRO_AAF_DELT	ACCEL_AAF_DELTSQR; GYRO_AAF_DELTSQR	ACCEL_AAF_BITSHIFT; GYRO_AAF_BITSHIFT
10	1	1	15
21	2	4	13
32	3	9	12
42	4	16	11
53	5	25	10
64	6	36	10
76	7	49	9
87	8	64	9
99	9	81	9
110	10	100	8
122	11	122	8
134	12	144	8
146	13	170	8
158	14	196	7
171	15	224	7
184	16	256	7
196	17	288	7
209	18	324	7
222	19	360	6
236	20	400	6
249	21	440	6
263	22	488	6
277	23	528	6
291	24	576	6
305	25	624	6
319	26	680	6
334	27	736	5
349	28	784	5

364	29	848	5
379	30	896	5
394	31	960	5
410	32	1024	5
425	33	1088	5
441	34	1152	5
458	35	1232	5
474	36	1296	5
490	37	1376	4
507	38	1440	4
524	39	1536	4
541	40	1600	4
559	41	1696	4
576	42	1760	4
594	43	1856	4
612	44	1952	4
631	45	2016	4
649	46	2112	4
668	47	2208	4
687	48	2304	4
706	49	2400	4
725	50	2496	4
745	51	2592	4
764	52	2720	4
784	53	2816	3
804	54	2944	3
825	55	3008	3
845	56	3136	3
866	57	3264	3
887	58	3392	3
908	59	3456	3
930	60	3584	3
951	61	3712	3
973	62	3840	3
995	63	3968	3

The anti-alias filter can be selected or bypassed for the gyroscope by using the parameter GYRO\_AAF\_DIS in register bank 1, register 0x0Bh, bit 1 as shown below.

GYRO_AAF_DIS	Function
0	Enable gyroscope anti-aliasing filter
1	Disable gyroscope anti-aliasing filter

The anti-alias filter can be selected or bypassed for the accelerometer by using the parameter ACCEL\_AAF\_DIS in register bank 2, register 0x03h, bit 0 as shown below.

ACCEL_AAF_DIS	Function
0	Enable accelerometer anti-aliasing filter
1	Disable accelerometer anti-aliasing filter

## 5.4 USER PROGRAMMABLE OFFSET

Gyroscope and accelerometer offsets can be programmed by the user by using registers OFFSET\_USER0, through OFFSET\_USER8, in bank 0, registers 0x77h through 0x7Fh (bank 4) as shown below.

Register Address	Register Name	Bits	Function
0x77h	OFFSET_USER0	7:0	Lower bits of X-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.
0x78h	OFFSET_USER1	3:0	Upper bits of X-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.
		7:4	Upper bits of Y-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.
0x79h	OFFSET_USER2	7:0	Lower bits of Y-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.
0x7Ah	OFFSET_USER3	7:0	Lower bits of Z-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.
0x7Bh	OFFSET_USER4	3:0	Upper bits of Z-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.
		7:4	Upper bits of X-accel offset programmed by user. Max value is $\pm 1$ g, resolution is 0.5 g.
0x7Ch	OFFSET_USER5	7:0	Lower bits of X-accel offset programmed by user. Max value is $\pm 1$ g, resolution is 0.5 g.
0x7Dh	OFFSET_USER6	7:0	Lower bits of Y-accel offset programmed by user. Max value is $\pm 1$ g, resolution is 0.5 g.
0x7Eh	OFFSET_USER7	3:0	Upper bits of Y-accel offset programmed by user. Max value is $\pm 1$ g, resolution is 0.5 g.
		7:4	Upper bits of Z-accel offset programmed by user. Max value is $\pm 1$ g, resolution is 0.5 g.
0x7Fh	OFFSET_USER8	7:0	Lower bits of Z-accel offset programmed by user. Max value is $\pm 1$ g, resolution is 0.5 g.

## 5.5 UI FILTER BLOCK

The UI filter block can be programmed to select filter order and bandwidth independently for gyroscope and accelerometer.

Gyroscope filter order can be selected by programming the parameter GYRO\_UI\_FILT\_ORD in register bank 0, register 0x51h, bits 3:2, as shown below.

GYRO_UI_FILT_ORD	Filter Order
00	1 <sup>st</sup> order
01	2 <sup>nd</sup> order
10	3 <sup>rd</sup> order
11	Reserved

Accelerometer filter order can be selected by programming the parameter ACCEL\_UI\_FILT\_ORD in register bank 0, register 0x53h, bits 4:3, as shown below.

ACCEL_UI_FILT_ORD	Filter Order
00	1 <sup>st</sup> order
01	2 <sup>nd</sup> order
10	3 <sup>rd</sup> order
11	Reserved

Gyroscope and accelerometer filter 3dB bandwidth can be selected by programming the parameter GYRO\_UI\_FILT\_BW in register bank 0, register 0x52h, bits 3:0, and the parameter ACCEL\_UI\_FILT\_BW in register bank 0, register 0x52h, bits 7:4, as shown below. The values shown in bold correspond to low power and the values shown in italics correspond to low latency. User can select the appropriate setting based on the application requirements for power and latency. Corresponding Noise Bandwidth (NBW) and Group Delay values are also shown.

### 1<sup>st</sup> Order Filter 3dB Bandwidth, Noise Bandwidth (NBW), Group Delay

	3dB Bandwidth (Hz) for GYRO/ACCEL_UI_FILT_ORD=0 (1st order filter)										
		GYRO/ACCEL_UI_FILT_BW									
GYRO/ACCEL_ODR	ODR(Hz)	0	1	2	3	4	5	6	7	14	15
3	8000	2096.30									
4	4000	1048.10									
5	2000	524.00									
6	1000	498.30	227.20	188.90	111.00	92.40	59.60	48.80	23.90	262.00	2096.30
15	500	249.10	113.60	94.40	55.50	46.20	29.80	24.40	11.90	131.00	1048.10
7	200	99.60	50.00	75.50	44.40	37.00	23.80	19.50	9.60	104.80	419.20
8	100	49.80	90.90	75.50	44.40	37.00	23.80	19.50	9.60	104.80	209.60
9	50	24.90	90.90	75.50	44.40	37.00	23.80	19.50	9.60	104.80	104.80
10	25	12.50	90.90	75.50	44.40	37.00	23.80	19.50	9.60	104.80	52.40
11	12.5	12.50	90.90	75.50	44.40	37.00	23.80	19.50	9.60	104.80	52.40

	NBW Bandwidth (Hz) for GYRO/ACCEL_UI_FILT_ORD=0 (1st order filter)										
		GYRO/ACCEL_UI_FILT_BW									
GYRO/ACCEL_ODR	ODR(Hz)	0	1	2	3	4	5	6	7	14	15
3	8000	2204.59									
4	4000	1102.23									
5	2000	551.13									
6	1000	551.13	230.84	196.28	126.46	108.92	75.80	64.06	34.08	275.59	2204.59
15	500	280.53	115.45	98.16	63.25	54.49	37.92	32.05	17.07	137.82	1102.23
7	200	112.24	92.37	78.54	50.61	43.60	30.35	25.65	13.66	110.26	440.91
8	100	56.15	92.37	78.54	50.61	43.60	30.35	25.65	13.66	110.26	220.48
9	50	28.10	92.37	78.54	50.61	43.60	30.35	25.65	13.66	110.26	110.26
10	25	14.07	92.37	78.54	50.61	43.60	30.35	25.65	13.66	110.26	55.16
11	12.5	14.07	92.37	78.54	50.61	43.60	30.35	25.65	13.66	110.26	55.16

Group Delay @DC (ms) for GYRO/ACCEL_UI_FILT_ORD=0 (1st order filter)											
		GYRO/ACCEL_UI_FILT_BW									
GYRO/ACCEL_ODR	ODR(Hz)	0	1	2	3	4	5	6	7	14	15
3	8000	0.24									
4	4000	0.43									
5	2000	0.80									
6	1000	0.57	1.80	2.02	2.75	3.08	4.09	4.70	8.15	1.55	0.24
15	500	1.10	3.55	3.98	5.45	6.10	8.13	9.35	16.24	3.05	0.43
7	200	2.66	4.43	4.97	6.81	7.62	10.15	11.67	20.29	3.79	0.99
8	100	5.28	4.43	4.97	6.81	7.62	10.15	11.67	20.29	3.79	1.92
9	50	10.50	4.43	4.97	6.81	7.62	10.15	11.67	20.29	3.79	3.79
10	25	20.95	4.43	4.97	6.81	7.62	10.15	11.67	20.29	3.79	7.54
11	12.5	20.95	4.43	4.97	6.81	7.62	10.15	11.67	20.29	3.79	7.54

## 2<sup>nd</sup> Order Filter 3dB Bandwidth, Noise Bandwidth (NBW), Group Delay

3dB Bandwidth (Hz) for GYRO/ACCEL_UI_FILT_ORD=1 (2nd order filter)											
		GYRO/ACCEL_UI_FILT_BW									
GYRO/ACCEL_ODR	ODR(Hz)	0	1	2	3	4	5	6	7	14	15
3	8000	2026.30									
4	4000	1048.10									
5	2000	524.00									
6	1000	493.30	230.70	151.60	117.50	97.10	59.60	48.00	21.30	262.00	2096.30
15	500	246.70	115.30	95.80	58.80	48.50	29.80	24.00	10.60	131.00	1048.10
7	200	98.70	52.30	76.60	47.00	38.80	23.80	19.20	8.50	104.80	419.20
8	100	49.30	92.30	76.60	47.00	38.80	23.80	19.20	8.50	104.80	209.60
9	50	24.70	92.30	76.60	47.00	38.80	23.80	19.20	8.50	104.80	104.80
10	25	12.30	92.30	76.60	47.00	38.80	23.80	19.20	8.50	104.80	52.40
11	12.5	12.30	92.30	76.60	47.00	38.80	23.80	19.20	8.50	104.80	52.40

NBW Bandwidth (Hz) for GYRO/ACCEL_UI_FILT_ORD=1 (2nd order filter)											
		GYRO/ACCEL_UI_FILT_BW									
GYRO/ACCEL_ODR	ODR(Hz)	0	1	2	3	4	5	6	7	14	15
3	8000	2204.59									
4	4000	1102.23									
5	2000	551.13									
6	1000	551.13	223.73	189.95	122.70	102.82	64.66	52.50	23.72	275.59	2204.59
15	500	259.58	111.89	95.00	61.38	51.44	32.36	26.28	11.89	137.82	1102.23
7	200	103.86	89.52	76.01	49.11	41.16	25.89	21.03	9.52	110.26	440.91
8	100	51.96	89.52	76.01	49.11	41.16	25.89	21.03	9.52	110.26	220.48
9	50	26.00	89.52	76.01	49.11	41.16	25.89	21.03	9.52	110.26	110.26
10	25	13.03	89.52	76.01	49.11	41.16	25.89	21.03	9.52	110.26	55.16
11	12.5	13.03	89.52	76.01	49.11	41.16	25.89	21.03	9.52	110.26	55.16

Group Delay @DC (ms) for GYRO/ACCEL_UI_FILT_ORD=1 (2nd order filter)											
GYRO/ACCEL_ODR	ODR(Hz)	GYRO/ACCEL_UI_FILT_BW									
		0	1	2	3	4	5	6	7	14	15
3	8000	0.24									
4	4000	0.43									
5	2000	0.80									
6	1000	0.69	2.06	2.36	3.25	3.69	5.21	6.14	12.03	1.55	0.24
15	500	1.34	4.07	4.66	6.44	7.32	10.36	12.23	24.01	3.05	0.43
7	200	3.26	5.08	5.81	8.04	9.14	12.94	15.27	29.99	3.79	0.99
8	100	6.48	5.08	5.81	8.04	9.14	12.94	15.27	29.99	3.79	1.92
9	50	12.90	5.08	5.81	8.04	9.14	12.94	15.27	29.99	3.79	3.79
10	25	25.75	5.08	5.81	8.04	9.14	12.94	15.27	29.99	3.79	7.54
11	12.5	25.75	5.08	5.81	8.04	9.14	12.94	15.27	29.99	3.79	7.54

### 3<sup>rd</sup> Order Filter 3dB Bandwidth, Noise Bandwidth (NBW), Group Delay

3dB Bandwidth (Hz) for GYRO/ACCEL_UI_FILT_ORD=2 (3rd order filter)											
GYRO/ACCEL_ODR	ODR(Hz)	GYRO/ACCEL_UI_FILT_BW									
		0	1	2	3	4	5	6	7	14	15
3	8000	2026.30									
4	4000	1048.10									
5	2000	524.00									
6	1000	492.90	234.70	195.80	118.90	97.90	60.80	46.80	25.20	262.00	2096.30
15	500	246.40	117.40	97.90	59.50	48.90	30.40	23.40	12.60	131.00	1048.10
7	200	98.90	53.90	47.60	39.20	24.30	18.70	10.10	104.80	419.20	
8	100	49.30	93.90	78.30	47.60	39.20	24.30	18.70	10.10	104.80	209.60
9	50	24.60	93.90	78.30	47.60	39.20	24.30	18.70	10.10	104.80	104.80
10	25	12.30	93.90	78.30	47.60	39.20	24.30	18.70	10.10	104.80	52.40
11	12.5	12.30	93.90	78.30	47.60	39.20	24.30	18.70	10.10	104.80	52.40

NBW Bandwidth (Hz) for GYRO/ACCEL_UI_FILT_ORD=2 (3rd order filter)											
GYRO/ACCEL_ODR	ODR(Hz)	GYRO/ACCEL_UI_FILT_BW									
		0	1	2	3	4	5	6	7	14	15
3	8000	2204.59									
4	4000	1102.23									
5	2000	551.13									
6	1000	551.13	221.34	188.47	120.11	99.96	62.95	48.58	26.36	275.59	2204.59
15	500	251.96	110.69	94.26	60.08	50.00	31.50	24.31	13.20	137.82	1102.23
7	200	100.82	88.56	75.42	48.07	40.01	25.21	19.46	10.57	110.26	440.91
8	100	50.43	88.56	75.42	48.07	40.01	25.21	19.46	10.57	110.26	220.48
9	50	25.24	88.56	75.42	48.07	40.01	25.21	19.46	10.57	110.26	110.26
10	25	12.65	88.56	75.42	48.07	40.01	25.21	19.46	10.57	110.26	55.16
11	12.5	12.65	88.56	75.42	48.07	40.01	25.21	19.46	10.57	110.26	55.16

Group Delay @DC (ms) for GYRO/ACCEL_UI_FILT_ORD=2 (3rd order filter)											
		GYRO/ACCEL_UI_FILT_BW									
GYRO/ACCEL_ODR	ODR(Hz)	0	1	2	3	4	5	6	7	14	15
3	8000	0.24									
4	4000	0.43									
5	2000	0.80									
6	1000	0.85	2.34	2.75	3.97	4.60	6.65	8.20	14.09	1.55	0.24
15	500	1.64	4.63	5.45	7.89	9.15	13.25	16.35	28.14	3.05	0.43
7	200	4.02	5.77	6.80	9.84	11.42	16.54	20.42	35.16	3.79	0.99
8	100	7.99	5.77	6.80	9.84	11.42	16.54	20.42	35.16	3.79	1.92
9	50	15.92	5.77	6.80	9.84	11.42	16.54	20.42	35.16	3.79	3.79
10	25	31.80	5.77	6.80	9.84	11.42	16.54	20.42	35.16	3.79	7.54
11	12.5	31.80	5.77	6.80	9.84	11.42	16.54	20.42	35.16	3.79	7.54

## 5.6 ODR AND FSR SELECTION

Gyroscope ODR can be selected by programming the parameter GYRO\_ODR in register bank 0, register 0x4Fh, bits 3:0 as shown below.

GYRO_ODR	Gyroscope ODR Value
0000	Reserved
0001	Reserved
0010	Reserved
0011	8kHz
0100	4kHz
0101	2kHz
0110	1kHz (default)
0111	200Hz
1000	100Hz
1001	50Hz
1010	25Hz
1011	12.5Hz
1100	Reserved
1101	Reserved
1110	Reserved
1111	500Hz

Gyroscope FSR can be selected by programming the parameter GYRO\_FS\_SEL in register bank 0, register 0x4Fh, bits 7:5 as shown below.

GYRO_FS_SEL	Gyroscope FSR Value
000	2000dps
001	1000dps



010	500dps
011	250dps
100	125dps
101	62.5dps
110	31.25dps
111	15.625dps

Accelerometer ODR can be selected by programming the parameter ACCEL\_ODR in register bank 0, register 0x50h, bits 3:0 as shown below.

ACCEL_ODR	Accelerometer ODR Value
0000	Reserved
0001	Reserved
0010	Reserved
0011	8kHz (LN mode)
0100	4kHz (LN mode)
0101	2kHz (LN mode)
0110	1kHz (LN mode) (default)
0111	200Hz (LP or LN mode)
1000	100Hz (LP or LN mode)
1001	50Hz (LP or LN mode)
1010	25Hz (LP or LN mode)
1011	12.5Hz (LP or LN mode)
1100	6.25Hz (LP mode)
1101	3.125Hz (LP mode)
1110	1.5625Hz (LP mode)
1111	500Hz (LP or LN mode)

Accelerometer FSR can be selected by programming the parameter ACCEL\_FS\_SEL in register bank 0, register 0x50h, bits 7:5 as shown below.

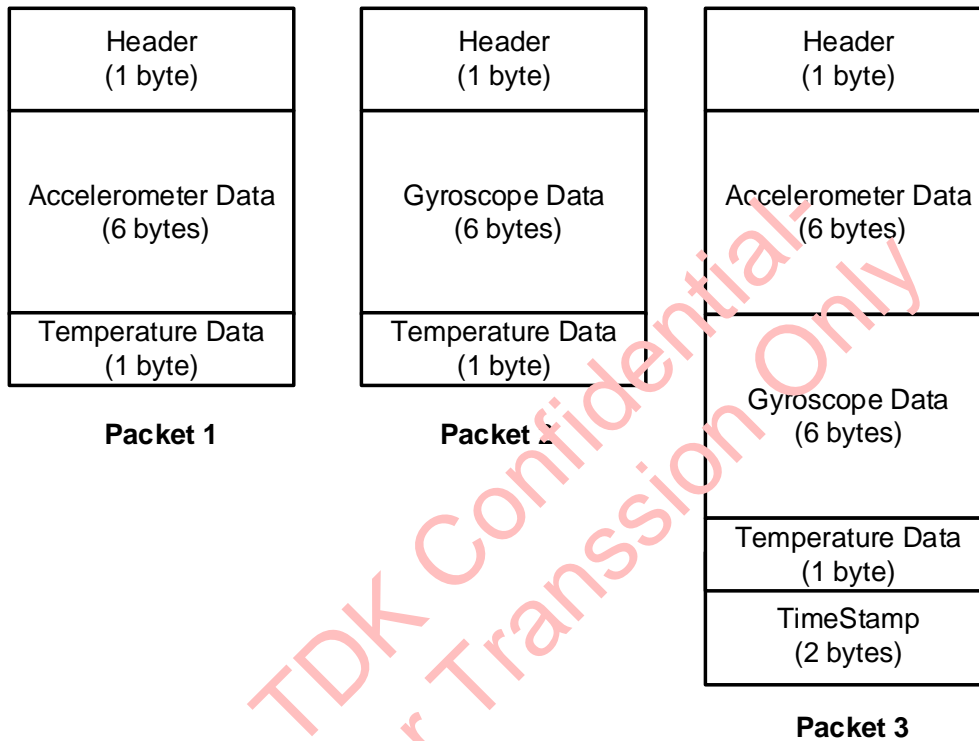
ACCEL_FS_SEL	Accelerometer FSR Value
000	16g
001	8g
010	4g
011	2g
100	Reserved
101	Reserved
110	Reserved
111	Reserved

## 6 FIFO

The ICM-40607 contains a 2K byte FIFO register that is accessible via the serial interface. The FIFO configuration register determines which data is written into the FIFO. Possible choices include gyroscope data, accelerometer data, and temperature readings. A FIFO counter keeps track of how many bytes of valid data are contained in the FIFO.

### 6.1 PACKET STRUCTURE

The following figure shows the FIFO packet structures supported in ICM-40607.



**Figure 11. FIFO Packet Structure**

The rest of this sub-section describes how individual data is packaged in the different FIFO packet structures.

**Packet 1:** Individual data is packaged in Packet 1 as shown below.

Byte	Content
0x00	FIFO Header
0x01	Accel X [15:8]
0x02	Accel X [7:0]
0x03	Accel Y [15:8]
0x04	Accel Y [7:0]
0x05	Accel Z [15:8]
0x06	Accel Z [7:0]
0x07	Temperature[7:0]

**Packet 2:** Individual data is packaged in Packet 2 as shown below.

Byte	Content
0x00	FIFO Header
0x01	Gyro X [15:8]
0x02	Gyro X [7:0]
0x03	Gyro Y [15:8]
0x04	Gyro Y [7:0]
0x05	Gyro Z [15:8]
0x06	Gyro Z [7:0]
0x07	Temperature[7:0]

**Packet 3:** Individual data is packaged in Packet 3 as shown below.

Byte	Content
0x00	FIFO Header
0x01	Accel X [15:8]
0x02	Accel X [7:0]
0x03	Accel Y [15:8]
0x04	Accel Y [7:0]
0x05	Accel Z [15:8]
0x06	Accel Z [7:0]
0x07	Gyro X [15:8]
0x08	Gyro X [7:0]
0x09	Gyro Y [15:8]
0x0A	Gyro Y [7:0]
0x0B	Gyro Z [15:8]
0x0C	Gyro Z [7:0]
0x0D	Temperature[7:0]
0x0E	TimeStamp[15:8]
0x0F	TimeStamp[7:0]

## 6.2 FIFO HEADER

The following table shows the structure of the 1 byte FIFO header.

Bit Field	Item	Description
7	HEADER_MSG	1: FIFO is empty 0: Packet contains sensor data
6	HEADER_ACCEL	1: Packet is sized so that accel data have location in the packet, FIFO_ACCEL_EN must be 1 0: Packet does not contain accel sample
5	HEADER_GYRO	1: Packet is sized so that gyro data have location in the packet, FIFO_GYRO_EN must be 1 0: Packet does not contain gyro sample
3:2	HEADER_TIMESTAMP_FSYNC	00: Packet does not contain timestamp or FSYNC time data 01: Reserved 10: Packet contains ODR Timestamp

		11: Packet contains FSYNC time, and this packet is flagged as first ODR after FSYNC (only if FIFO_TMST_FSYNC_EN is 1)
1	HEADER_ODR_ACCEL	1: The ODR for accel is different for this accel data packet compared to the previous accel packet 0: The ODR for accel is the same as the previous packet with accel
0	HEADER_ODR_GYRO	1: The ODR for gyro is different for this gyro data packet compared to the previous accel packet 0: The ODR for gyro is the same as the previous packet with accel

Note at least HEADER\_ACCEL or HEADER\_GYRO must be set for a sensor data packet to be set.

### 6.3 MAXIMUM FIFO STORAGE

The maximum number of packets that can be stored in FIFO is a variable quantity depending on the use case. As shown in the figure below, the physical FIFO size is 2048 bytes. A number of bytes equal to the packet size selected (see section 6.1) is reserved to prevent reading a packet during write operation. Additionally, a read cache 2 packets wide is available.

When there is no serial interface operation, the read cache is not available for storing packets, being fed by the serial interface clock.

When serial interface operation happens, depending on the operation length and the packet size chosen, either 1 or 2 of the packet entries in read cache may become available for storing packets. In that case the total storage available is up to the maximum number of packets that can be accommodated in 2048 bytes + 1 packet size depending on the packet size used.

Due to the non-deterministic nature of system operation, driver memory allocation should always be the largest size of 2080 bytes.

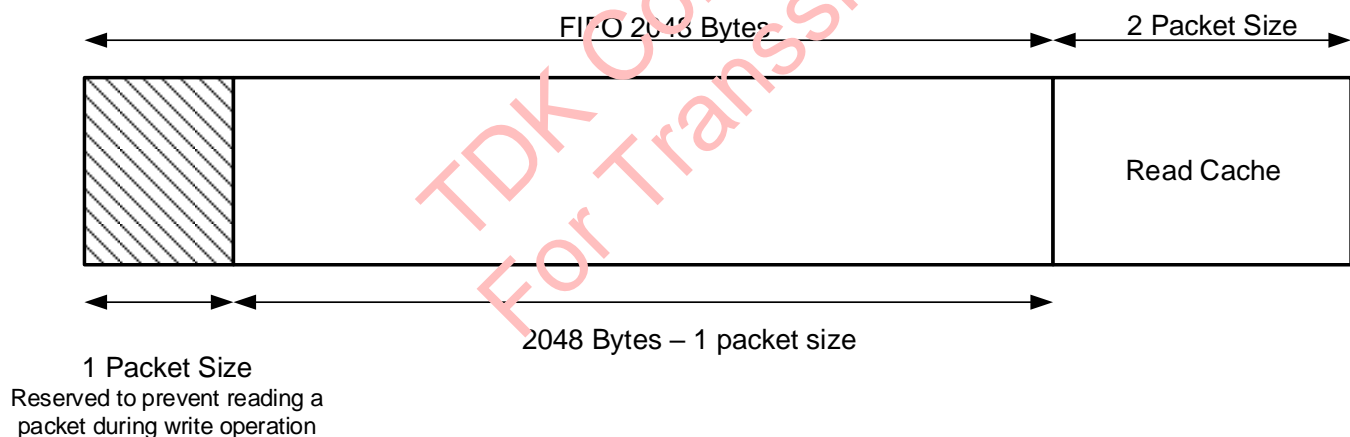


Figure 12. Maximum FIFO Storage

### 6.4 FIFO CONFIGURATION REGISTERS

The following control bits in bank 0, register 0x5Fh determine what data is placed into the FIFO. The values of these bits may change while the FIFO is being filled without corruption of the FIFO.

BIT	NAME	FUNCTION
3	FIFO_TMST_FSYNC_EN	0: FIFO will only contain ODR timestamp information 1: FIFO can also contain FSYNC time and FSYNC tag for one ODR after an FSYNC event
1	FIFO_GYRO_EN	0: Default setting; Gyroscope data not placed into FIFO 1: Enables gyroscope data packets of 6-bytes to be placed in FIFO

0	FIFO_ACCEL_EN	0: Default setting; Accelerometer data not placed into FIFO 1: Enables accelerometer data packets of 6-bytes to be placed in FIFO
---	---------------	--

Configuration register settings above impact FIFO header and FIFO packet size as follows:

FIFO_ACCEL_EN	FIFO_GYRO_EN	FIFO_TMST_EN	Header	Packet size
1	1	0	8'b_0110_10xx	16 Bytes
1	1	1	8'b_0110_1xxx	16 Bytes
1	0	X	8'b_0100_00xx	8 Bytes
0	1	X	8'b_0010_00xx	8 Bytes
0	0	X	No FIFO writes	No FIFO writes

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## 7 PROGRAMMABLE INTERRUPTS

The ICM-40607 has a programmable interrupt system that can generate an interrupt signal on the INT pins. Status flags indicate the source of an interrupt. Interrupt sources may be enabled and disabled individually. There are two interrupt outputs. Any interrupt may be mapped to either interrupt pin as explained in the register section. The following configuration options are available for the interrupts

- INT1 and INT2 can be push-pull or open drain
- Level or pulse mode
- Active high or active low

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## 8 APEX MOTION FUNCTIONS

The APEX (Advanced Pedometer and Event Detection – neXt gen) features of ICM-40607 consist of:

- Pedometer: Tracks Step count and issues a Step Detect Interrupt
- Tilt Detection: Issues an interrupt when the Tilt angle exceeds 35 degrees for more than a programmable time.
- Raise to Wake/Sleep: Gesture detection for wake and sleep events. Interrupt is issued when either of these two events are detected.
- Tap Detection: Issues an interrupt when Tap is detected, along with a register containing the Tap Count.
- Wake on Motion (WoM): Detects motion when accelerometer samples exceed a programmable threshold. This motion event can be used to enable chip operation from sleep mode.
- Significant Motion Detector (SMD): Detects motion if WoM events are detected during a programmable time window (2s or 4s).

### 8.1 APEX ODR SUPPORT

APEX algorithms are designed to work with the accelerometer, for a variety of ODR settings. However, there is a minimum ODR required for each algorithm. The following table shows the relationship between the available accelerometer ODRs and the operation of the APEX algorithms. In order to allow more flexible operation where we can control the ODR of the APEX algorithms independent of the accelerometer ODR, we allow for an additional selection determined by the field DMP\_ODR (DMP stands for Digital Motion Processor™, an architectural component of APEX). The tables below show how DMP\_ODR should be configured in relation to the accelerometer ODR and the expected performance.

Accel ODR	DMP_ODR	Tap Detection	Pedometer	Tilt Detection	Raise to Wake/Sleep
< 25Hz	X	Disabled	Disabled	Disabled	Disabled
≥ 25Hz	0 (25Hz)	Disabled	Low Power	Low Power	Enabled
≥ 50Hz	2 (50Hz)	Disabled	Normal	Normal	Enabled

Accel ODR	Tap Detection
200Hz	Low Power
500Hz	Normal
1kHz	High Performance
> 1kHz	Disabled

If the accelerometer ODR is set below the minimum DMP ODR (25 Hz), the APEX features cannot be enabled.

When the accelerometer ODR needs to be set differently from the DMP ODR, only the integer multiple of DMP ODR for accelerometer sensor ODR is suitable to use with DMP. For example, when the accelerometer ODR is set as 200 Hz, the APEX features can be enabled with choices of 25 Hz, or 50 Hz, depending on the DMP\_ODR register setting.

DMP ODR should not be changed on the fly. The following sequence should be followed for changing the DMP ODR:

1. Disable Pedometer, and Tilt Detection if they are enabled
2. Change DMP ODR
3. Set DMP\_INIT\_EN for one cycle (Register 0x4Bh in Bank 0)
4. Unset DMP\_INIT\_EN (Register 0x4Bh in Bank 0)
5. Enable APEX features of interest

## 8.2 DMP POWER SAVE MODE

DMP Power Save Mode can be enabled or disabled by DMP\_POWER\_SAVE (Register 0x56h in Bank 0). When the DMP Power Save Mode is enabled, APEX features are enabled only when WOM is detected. WOM must be explicitly enabled for the DMP to work in this mode. When WOM is not detected the APEX features are on pause. If the user does not want to use DMP Power Save Mode they may set DMP\_POWER\_SAVE = 0, and use APEX functions without WOM detection.

## 8.3 PEDOMETER PROGRAMMING

- Pedometer configuration parameters
  1. LOW\_ENERGY\_AMP\_TH\_SEL (Register 0x40h in Bank 4)
  2. PED\_AMP\_TH\_SEL (Register 0x41h in Bank 4)
  3. PED\_STEP\_CNT\_TH\_SEL (Register 0x41h in Bank 4)
  4. PED\_HI\_EN\_TH\_SEL (Register 0x42h in Bank 4)
  5. PED\_SB\_TIMER\_TH\_SEL (Register 0x42h in Bank 4)
  6. PED\_STEP\_DET\_TH\_SEL (Register 0x42h in Bank 4)
  7. SENSITIVITY\_MODE (Register 0x48h in Bank 4)
  8. There are 2 ODR and 2 sensitivity modes

Accel ODR (DMP_ODR)	normal	slow walk
25 Hz (0)	low power	low power and slow walk
50 Hz (2)	high performance	slow walk

- Initialize Sensor in a typical configuration
  1. Set accelerometer ODR to 50 Hz (Register 0x50h in Bank 0)
  2. Set accelerometer to Low Power mode (Register 0x4Eh in Bank 0)  
ACCEL\_MODE = 2 and (Register 0x4Eh in Bank 0), ACCEL\_LP\_CLK\_SEL = 0, for low power mode
  3. Set DMP ODR = 50 Hz and turn on Pedometer feature (Register 0x56h in Bank 0)
  4. Wait 1 millisecond
- Initialize APEX hardware
  1. Set DMP\_MEM\_RESET\_EN to 1 (Register 0x4Bh in Bank 0)
  2. Wait 1 millisecond
  3. Set LOW\_ENERGY\_AMP\_TH\_SEL to 10 (Register 0x40h in Bank 4)
  4. Set PED\_AMP\_TH\_SEL to 8 (Register 0x41h in Bank 4)
  5. Set PED\_STEP\_CNT\_TH\_SEL to 5 (Register 0x41h in Bank 4)
  6. Set PED\_HI\_EN\_TH\_SEL to 1 (Register 0x42h in Bank 4)
  7. Set PED\_SB\_TIMER\_TH\_SEL to 4 (Register 0x42h in Bank 4)
  8. Set PED\_STEP\_DET\_TH\_SEL to 2 (Register 0x42h in Bank 4)
  9. Set SENSITIVITY\_MODE to 0 (Register 0x48h in Bank 4)
  10. Set DMP\_INIT\_EN to 1 (Register 0x4Bh in Bank 0)
  11. Enable STEP detection, source for INT1 by setting bit 5 in register INT\_SOURCE6 (Register 0x4Dh in Bank 4) to 1. Or if INT2 is selected for STEP detection, enable STEP detection source by setting bit 5 in register INT\_SOURCE7 (Register 0x4Eh in Bank 4) to 1.
  12. Wait 50 milliseconds
  13. Turn on Pedometer feature by setting PED\_ENABLE to 1 (Register 0x56h in Bank 0)



- Output registers
  1. Read interrupt register (Register 0x7Eh in Bank 0) for STEP\_DET\_INT
  2. If the step count is equal to or greater than 65535 (uint16), the STEP\_CNT\_OVF\_INT (Register 0x7Eh in Bank 0) will be set to 1. Example:
    - Take 1 step => output step count = 65533 (real step count is 65533)
    - Take 1 step => output step count = 65534 (real step count is 65534)
    - Take 1 step => output step count = 0 and interrupt is fired (real step count is 65535+0= 65535)
    - Take 1 step => output step count = 1 (real step count is 65535+1=65536)
  3. Read the step count in STEP\_CNT (Register 0x31h and 0x32h in Bank 0)
  4. Read the step cadence in STEP\_CADENCE (Register 0x33h in Bank 0)
  5. Read the activity class in ACTIVITY\_CLASS (Register 0x34h in Bank 0)

## 8.4 TILT DETECTION PROGRAMMING

- Tilt Detection configuration parameters
  1. TILT\_WAIT\_TIME (Register 0x43h in Bank 4)  
This parameter configures how long of a delay after tilt is detected before interrupt is triggered  
Default is 2 (4 s).  
Range is 0 = 0 s, 1 = 2 s, 2 = 4 s, 3 = 6 s  
For example, setting TILT\_WAIT\_TIME = 2 is equivalent to 4 seconds for all ODRs
- Initialize Sensor in a typical configuration
  1. Set accelerometer ODR (Register 0x50h in Bank 0)  
ACCEL\_ODR = 9 for 50 Hz or 10 for 25 Hz
  2. Set Accel to Low Power mode (Register 0x4Eh in Bank 0)  
ACCEL\_MODE = 2 and (Register 0x4Dh in Bank 0), ACCEL\_LP\_CLK\_SEL = 0, for low power mode
  3. Set DMP ODR (Register 0x56h in Bank 0)  
DMP\_ODR = 0 for 25 Hz, 2 for 50 Hz
  4. Wait 1 millisecond
- Initialize APEX hardware
  1. Set DMP\_MEM\_RESET\_EN to 1 (Register 0x4Bh in Bank 0)
  2. Wait 1 millisecond
  3. Set TILT\_WAIT\_TIME (Register 0x43h in Bank 4) if default value does not meet needs
  4. Wait 1 millisecond
  5. Set DMP\_INIT\_EN to 1 (Register 0x4Bh in Bank 0)
  6. Enable Tilt Detection, source for INT1 by setting bit 3 in register INT\_SOURCE6 (Register 0x4Dh in Bank 4) to 1. Or if INT2 is selected for Tilt Detection, enable Tilt Detection source by setting bit 3 in register INT\_SOURCE7 (Register 0x4Eh in Bank 4) to 1.
  7. Wait 50 milliseconds
  8. Turn on Tilt Detection feature by setting TILT\_ENABLE to 1 (Register 0x56h in Bank 0)
- Output registers
  1. Read interrupt register (Register 0x7Eh in Bank 0) for tilt which is bit 3

## 8.5 RAISE TO WAKE/SLEEP PROGRAMMING

- Raise to Wake/Sleep configuration parameters
  1. SLEEP\_TIME\_OUT (Register 0x43h in Bank 4)
  2. MOUNTING\_MATRIX (Register 0x44h in Bank 4)
  3. SLEEP\_GESTURE\_DELAY (Register 0x45h in Bank 4)
- Initialize Sensor in a typical configuration
  1. Set accelerometer ODR (Register 0x50h in Bank 0)  
ACCEL\_ODR = 10 for 25 Hz

2. Set Accel to Low Power mode (Register 0x4Eh in Bank 0)  
ACCEL\_MODE = 2 and (Register 0x4Dh in Bank 0), ACCEL\_LP\_CLK\_SEL = 0, for low power mode
  3. Set DMP ODR (Register 0x56h in Bank 0)  
DMP\_ODR = 0 for 25 Hz, 2 for 50 Hz
  4. Wait 1 millisecond
- Initialize APEX hardware
    1. Set DMP\_MEM\_RESET\_EN to 1 (Register 0x4Bh in Bank 0)
    2. Wait 1 millisecond
    3. Set SLEEP\_TIME\_OUT (Register 0x43h in Bank 4) if default value does not meet needs
    4. Wait 1 millisecond
    5. Set MOUNTING\_MATRIX (Register 0x44h in Bank 4) if default value does not meet needs
    6. Wait 1 millisecond
    7. Set SLEEP\_GESTURE\_DELAY (Register 0x45h in Bank 4) if default value does not meet needs
    8. Wait 1 millisecond
    9. Set DMP\_INIT\_EN to 1 (Register 0x4Bh in Bank 0)
    10. Enable Raise to Wake/Sleep, source for INT1 by setting bit 2,1 in register INT\_SOURCE6 (Register 0x4Dh in Bank 4) to 1. Or if INT2 is selected for Raise to Wake/Sleep, enable Raise to Wake/Sleep source by setting bit 2,1 in register INT\_SOURCE7 (Register 0x4Eh in Bank 4) to 1.
    11. Wait 50 milliseconds
    12. Turn on Raise to Wake/Sleep feature by setting R2W\_EN to 1 (Register 0x56h in Bank 0)
  - Output registers
    1. Read interrupt register (Register 0x38h in Bank 0) for Wake and Sleep event

## 8.6 TAP DETECTION PROGRAMMING

- Tap Detection configuration parameters
  1. TAP\_TMAX (Register 0x47h in Bank 4)
  2. TAP\_TMIN (Register 0x47h in Bank 4)
  3. TAP\_TAVG (Register 0x47h in Bank 4)
  4. TAP\_MIN\_JERK\_THR (Register 0x46h in Bank 4)
  5. TAP\_MAX\_PEAK\_TOL (Register 0x46h in Bank 4)
  6. TAP\_ENABLE (Register 0x56h in Bank 0)
- Initialize Sensor in a typical configuration
  1. Set accelerometer ODR (Register 0x50h in Bank 0)  
ACCEL\_ODR = 15 for 500 Hz (ODR of 200Hz or 1kHz may also be used)
  2. Set power modes and filter configurations as shown below
    - For ODR up to 500Hz, set Accel to Low Power mode (Register 0x4Eh in Bank 0)  
ACCEL\_MODE = 2 and ACCEL\_LP\_CLK\_SEL = 0, (Register 0x4Dh in Bank 0) for low power mode  
Set filter settings as follows: ACCEL\_DEC2\_M2\_ORD = 2 (Register 0x53h in Bank 0); ACCEL\_UI\_FILT\_BW = 4 (Register 0x52h in Bank 0)
    - For ODR of 1kHz, set Accel to Low Noise mode (Register 0x4Eh in Bank 0) ACCEL\_MODE = 1  
Set filter settings as follows: ACCEL\_UI\_FILT\_ORD = 2 (Register 0x53h in Bank 0); ACCEL\_UI\_FILT\_BW = 0 (Register 0x52h in Bank 0)
  3. Wait 1 millisecond
- Initialize APEX hardware
  1. Set TAP\_TMAX to 2 (Register 0x47h in Bank 4)
  2. Set TAP\_TMIN to 3 (Register 0x47h in Bank 4)
  3. Set TAP\_TAVG to 3 (Register 0x47h in Bank 4)
  4. Set TAP\_MIN\_JERK\_THR to 17 (Register 0x46h in Bank 4)
  5. Set TAP\_MAX\_PEAK\_TOL to 2 (Register 0x46h in Bank 4)

6. Wait 1 millisecond
  7. Enable TAP source for INT1 by setting bit 0 in register INT\_SOURCE6 (Register 0x4Dh in Bank 4) to 1. Or if INT2 is selected for TAP, enable TAP source by setting bit 0 in register INT\_SOURCE7 (Register 0x4Eh in Bank 4) to 1.
  8. Wait 50 milliseconds
  9. Turn on TAP feature by setting TAP\_ENABLE to 1 (Register 0x56h in Bank 0)
- Output registers
    1. Read interrupt register (Register 0x7Eh in Bank 0) for TAP\_DET\_INT
    2. Read the tap count in TAP\_NUM (Register 0x35h in Bank 0)
    3. Read the tap axis in TAP\_AXIS (Register 0x35h in Bank 0)
    4. Read the polarity of tap pulse in TAP\_DIR (Register 0x35h in Bank 0)

## 8.7 WAKE ON MOTION PROGRAMMING

- Wake on Motion configuration parameters
  1. WOM\_X\_TH (Register 0x4Ah in Bank 4)
  2. WOM\_Y\_TH (Register 0x4Bh in Bank 4)
  3. WOM\_Z\_TH (Register 0x4Ch in Bank 4)
  4. WOM\_INT\_MODE (Register 0x57h in Bank 0)
  5. WOM\_MODE (Register 0x57h in Bank 0)
  6. SMD\_MODE (Register 0x57h in Bank 0)
- Initialize Sensor in a typical configuration
  1. Set accelerometer ODR (Register 0x50h in Bank 0)  
ACCEL\_ODR = 9 for 50 Hz
  2. Set Accel to Low Power mode (Register 0x4Eh in Bank 0)  
ACCEL\_MODE = 2 and (Register 0x4Dh in Bank 0). ACCEL\_LP\_CLK\_SEL = 0, for low power mode
  3. Wait 1 millisecond
- Initialize APEX hardware
  1. Set WOM\_X\_TH to 98 (Register 0x4Ah in Bank 4)
  2. Set WOM\_Y\_TH to 98 (Register 0x4Bh in Bank 4)
  3. Set WOM\_Z\_TH to 98 (Register 0x4Ch in Bank 4)
  4. Wait 1 millisecond
  5. Enable all 3 axes as WOM sources for INT1 by setting bits 2:0 in register INT\_SOURCE1 (Register 0x66h in Bank 0) to 1. Or if INT2 is selected for WOM, enable all 3 axes as WOM sources by setting bits 2:0 in register INT\_SOURCE4 (Register 0x69h in Bank 0) to 1.
  6. Wait 50 milliseconds
  7. Turn on WOM feature by setting WOM\_INT\_MODE to 0, WOM\_MODE to 1, SMD\_MODE to 1 (Register 0x56h in Bank 0)
- Output registers
  1. Read interrupt register (Register 0x37h in Bank 0) for WOM\_X\_INT
  2. Read interrupt register (Register 0x37h in Bank 0) for WOM\_Y\_INT
  3. Read interrupt register (Register 0x37h in Bank 0) for WOM\_Z\_INT

## 8.8 SIGNIFICANT MOTION DETECTION PROGRAMMING

- Significant Motion Detection configuration parameters
  1. WOM\_X\_TH (Register 0x4Ah in Bank 4)
  2. WOM\_Y\_TH (Register 0x4Bh in Bank 4)
  3. WOM\_Z\_TH (Register 0x4Ch in Bank 4)
  4. WOM\_INT\_MODE (Register 0x57h in Bank 0)
  5. WOM\_MODE (Register 0x57h in Bank 0)
  6. SMD\_MODE (Register 0x57h in Bank 0)

- Initialize Sensor in a typical configuration
  1. Set accelerometer ODR (Register 0x50h in Bank 0)  
ACCEL\_ODR = 9 for 50 Hz
  2. Set Accel to Low Power mode (Register 0x4Eh in Bank 0)  
ACCEL\_MODE = 2 and (Register 0x4Dh in Bank 0), ACCEL\_LP\_CLK\_SEL = 0, for low power mode
  3. Wait 1 millisecond
- Initialize APEX hardware
  1. Set WOM\_X\_TH to 98 (Register 0x4Ah in Bank 4)
  2. Set WOM\_Y\_TH to 98 (Register 0x4Bh in Bank 4)
  3. Set WOM\_Z\_TH to 98 (Register 0x4Ch in Bank 4)
  4. Wait 1 millisecond
  5. Enable SMD source for INT1 by setting bit 3 in register INT\_SOURCE1 (Register 0x66h in Bank 0) to 1. Or if INT2 is selected for SMD, enable SMD source by setting bit 3 in register INT\_SOURCE4 (Register 0x69h in Bank 0) to 1.
  6. Wait 50 milliseconds
  7. Turn on SMD feature by setting WOM\_INT\_MODE to 0, WOM\_MODE to 1, SMD\_MODE to 3 (Register 0x56h in Bank 0)
- Output registers
  1. Read interrupt register (Register 0x37h in Bank 0) for SMD\_INT

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## 9 DIGITAL INTERFACE

### 9.1 I<sup>2</sup>C AND SPI SERIAL INTERFACES

The internal registers and memory of the ICM-40607 can be accessed using I<sup>2</sup>C at 1 MHz or SPI at 24 MHz. SPI operates in 3-wire or 4-wire mode. Pin assignments for serial interfaces are described in Section 4.1.

### 9.2 I<sup>2</sup>C INTERFACE

I<sup>2</sup>C is a two-wire interface comprised of the signals serial data (SDA) and serial clock (SCL). In general, the lines are open-drain and bi-directional. In a generalized I<sup>2</sup>C interface implementation, attached devices can be a master or a slave. The master device puts the slave address on the bus, and the slave device with the matching address acknowledges the master.

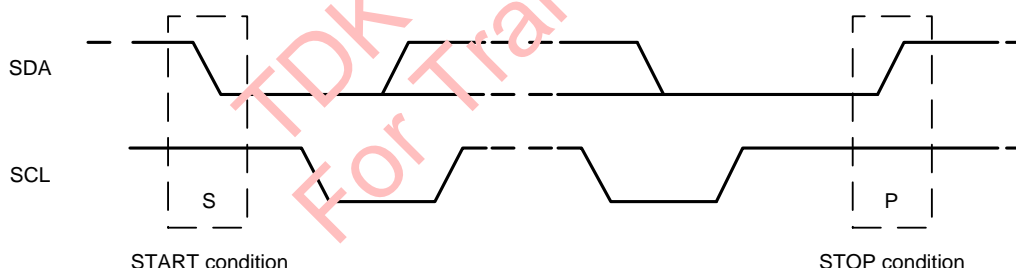
The ICM-40607 always operates as a slave device when communicating to the system processor, which thus acts as the master. SDA and SCL lines typically need pull-up resistors to VDDIO. The maximum bus speed is 1 MHz.

The slave address of the ICM-40607 is b110100X, which is 7 bits long. The LSB bit of the 7-bit address is determined by the logic level on pin AP\_AD0. This allows two ICM-40607s to be connected to the same I<sup>2</sup>C bus. When used in this configuration, the address of one of the devices should be b1101000 (pin AP\_AD0 is logic low) and the address of the other should be b1101001 (pin AP\_AD0 is logic high).

### 9.3 I<sup>2</sup>C COMMUNICATIONS PROTOCOL

#### START (S) and STOP (P) Conditions

Communication on the I<sup>2</sup>C bus starts when the master puts the START condition (S) on the bus, which is defined as a HIGH-to-LOW transition of the SDA line while SCL line is HIGH (see figure below). The bus is considered to be busy until the master puts a STOP condition (P) on the bus, which is defined as a LOW to HIGH transition on the SDA line while SCL is HIGH (see figure below). Additionally, the bus remains busy if a repeated START (S) is generated instead of a STOP condition.

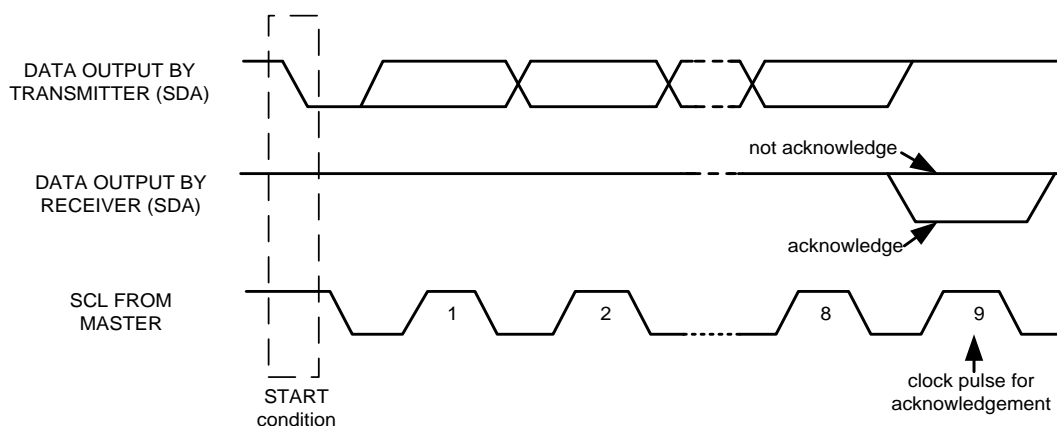


**Figure 13. START and STOP Conditions**

#### Data Format / Acknowledge

I<sup>2</sup>C data bytes are defined to be 8-bits long. There is no restriction to the number of bytes transmitted per data transfer. Each byte transferred must be followed by an acknowledge (ACK) signal. The clock for the acknowledge signal is generated by the master, while the receiver generates the actual acknowledge signal by pulling down SDA and holding it low during the HIGH portion of the acknowledge clock pulse.

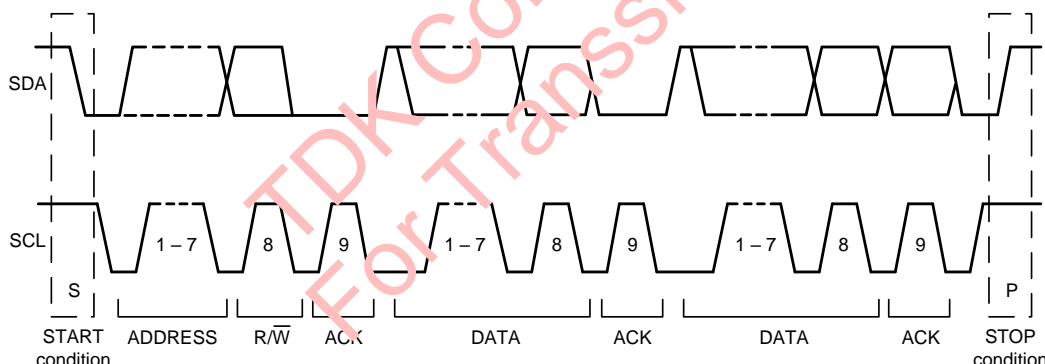
If a slave is busy and cannot transmit or receive another byte of data until some other task has been performed, it can hold SCL LOW, thus forcing the master into a wait state. Normal data transfer resumes when the slave is ready, and releases the clock line (refer to the following figure).



**Figure 14. Acknowledge on the I<sup>2</sup>C Bus**

### Communications

After beginning communications with the START condition (S), the master sends a 7-bit slave address followed by an 8<sup>th</sup> bit, the read/write bit. The read/write bit indicates whether the master is receiving data from or is writing to the slave device. Then, the master releases the SDA line and waits for the acknowledge signal (ACK) from the slave device. Each byte transferred must be followed by an acknowledge bit. To acknowledge, the slave device pulls the SDA line LOW and keeps it LOW for the high period of the SCL line. Data transmission is always terminated by the master with a STOP condition (P), thus freeing the communications line. However, the master can generate a repeated START condition (Sr), and address another slave without first generating a STOP condition (P). A LOW to HIGH transition on the SDA line while SCL is HIGH defines the stop condition. All SDA changes should take place when SCL is low, with the exception of start and stop conditions.



**Figure 15. Complete I<sup>2</sup>C Data Transfer**

To write the internal ICM-40607 registers, the master transmits the start condition (S), followed by the I<sup>2</sup>C address and the write bit (0). At the 9<sup>th</sup> clock cycle (when the clock is high), the ICM-40607 acknowledges the transfer. Then the master puts the register address (RA) on the bus. After the ICM-40607 acknowledges the reception of the register address, the master puts the register data onto the bus. This is followed by the ACK signal, and data transfer may be concluded by the stop condition (P). To write multiple bytes after the last ACK signal, the master can continue outputting data rather than transmitting a stop signal. In this case, the ICM-40607 automatically increments the register address and loads the data to the appropriate register. The following figures show single and two-byte write sequences.

### Single-Byte Write Sequence

Master	S	AD+W		RA		DATA		P
Slave			ACK		ACK		ACK	

## Burst Write Sequence

Master	S	AD+W		RA		DATA		DATA		P
Slave			ACK		ACK		ACK		ACK	

To read the internal ICM-40607 registers, the master sends a start condition, followed by the I<sup>2</sup>C address and a write bit, and then the register address that is going to be read. Upon receiving the ACK signal from the ICM-40607, the master transmits a start signal followed by the slave address and read bit. As a result, the ICM-40607 sends an ACK signal and the data. The communication ends with a not acknowledge (NACK) signal and a stop bit from master. The NACK condition is defined such that the SDA line remains high at the 9<sup>th</sup> clock cycle. The following figures show single and two-byte read sequences.

## Single-Byte Read Sequence

Master	S	AD+W		RA		S	AD+R			NACK	P
Slave			ACK		ACK			ACK	DATA		

## Burst Read Sequence

Master	S	AD+W		RA		S	AD+R			ACK		NACK	P
Slave			ACK		ACK			ACK	DATA		DATA		

## 9.4 I<sup>2</sup>C TERMS

Signal	Description
S	Start Condition: SDA goes from high to low while SCL is high
AD	Slave I <sup>2</sup> C address
W	Write bit (0)
R	Read bit (1)
ACK	Acknowledge: SDA line is low while the SCL line is high at the 9 <sup>th</sup> clock cycle
NACK	Not-Acknowledge: SDA line stays high at the 9 <sup>th</sup> clock cycle
RA	ICM-40607 internal register address
DATA	Transmit or received data
P	Stop condition: SDA going from low to high while SCL is high

Table 12. I<sup>2</sup>C Terms

## 9.5 SPI INTERFACE

The ICM-40607 supports 3-wire or 4-wire SPI for the host interface. The ICM-40607 always operates as a Slave device during standard Master-Slave SPI operation.

With respect to the Master, the Serial Clock output (SCLK), the Serial Data Output (SDO), the Serial Data Input (SDI), and the Serial Data IO (SDIO) are shared among the Slave devices. Each SPI slave device requires its own Chip Select (CS) line from the master.

CS goes low (active) at the start of transmission and goes back high (inactive) at the end. Only one CS line is active at a time, ensuring that only one slave is selected at any given time. The CS lines of the non-selected slave devices are held high, causing their SDO lines to remain in a high-impedance (high-z) state so that they do not interfere with any active devices.

### SPI Operational Features

1. Data is delivered MSB first and LSB last
2. Data is latched on the rising edge of SCLK
3. Data should be transitioned on the falling edge of SCLK
4. The maximum frequency of SCLK is 24 MHz
5. SPI read and write operations are completed in 16 or more clock cycles (two or more bytes). The first byte contains the SPI Address, and the following byte(s) contain(s) the SPI data. The first bit of the first byte contains the Read/Write bit and indicates the Read (1) or Write (0) operation. The following 7 bits contain the Register Address. In cases of multiple-byte Read/Writes, data is two or more bytes:

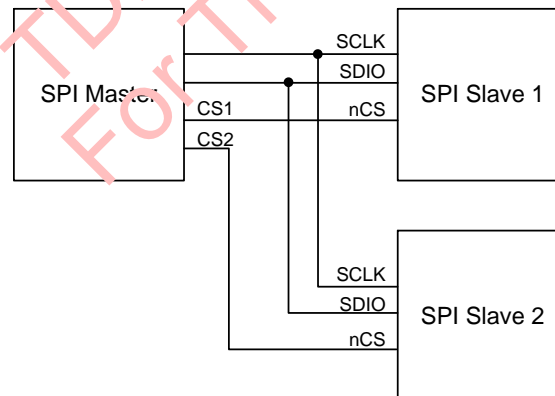
#### SPI Address format

MSB							LSB
R/W	A6	A5	A4	A3	A2	A1	A0

#### SPI Data format

MSB							LSB
D7	D6	D5	D4	D3	D2	D1	D0

6. Supports Single or Burst Read/Writes.



**Figure 16. Typical SPI Master/Slave Configuration**



## 10 ASSEMBLY

This section provides general guidelines for assembling InvenSense Micro Electro-Mechanical Systems (MEMS) devices packaged in LGA package.

### 10.1 ORIENTATION OF AXES

The diagram below shows the orientation of the axes of sensitivity and the polarity of rotation. Note the pin 1 identifier (•) in the figure.

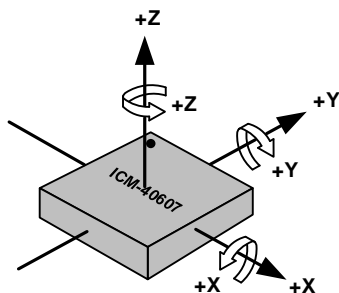


Figure 17. Orientation of Axes of Sensitivity and Polarity of Rotation.



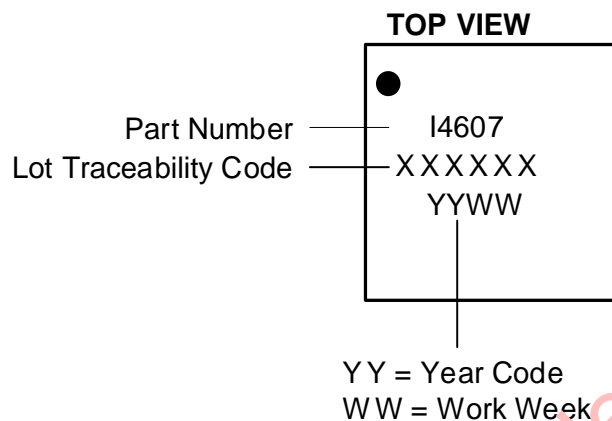
	SYMBOLS	DIMENSIONS IN MILLIMETERS		
		MIN	NOM	MAX
Total Thickness	A	0.85	0.91	0.97
Substrate Thickness	A1	0.105		REF
Mold Thickness	A2	0.8		REF
Body Size	D		2.5	BSC
	E		3	BSC
Lead Width	W	0.2	0.25	0.3
Lead Length	L	0.425	0.475	0.525
Lead Pitch	e	0.5		BSC
Lead Count	n	14		
Edge Pin Center to Center	D1	1.5		BSC
	E1	1		BSC
Body Center to Contact Pin	SD	0.25		BSC
Package Edge Tolerance	aaa	0.1		
Mold Flatness	bbb	0.2		
Coplanarity	ddd	0.08		

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## 11 PART NUMBER PACKAGE MARKING

The part number package marking for ICM-40607 devices is summarized below:

Part Number	Part Number Package Marking
ICM-40607	I4607



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## 12 USE NOTES

### 12.1 ACCELEROMETER MODE TRANSITIONS

When transitioning from accelerometer Low Power (LP) mode to accelerometer Low Noise (LN) mode, if ODR is 6.25Hz or lower, software should change ODR to a value of 12.5Hz or higher, because accelerometer LN mode does not support ODR values below 12.5Hz.

When transitioning from accelerometer LN mode to accelerometer LP mode, if ODR is greater than 500Hz, software should change ODR to a value of 500Hz or lower, because accelerometer LP mode does not support ODR values above 500Hz.

### 12.2 ACCELEROMETER LOW POWER (LP) MODE AVERAGING FILTER SETTING

Software drivers provided with the device use Averaging Filter setting of 16x. This setting is recommended for meeting Android noise requirements in LP mode, and to minimize accelerometer offset variation when transitioning from LP to Low Noise (LN) mode. 1x averaging filter can be used by following the setting configuration shown in section 14.38.

### 12.3 SETTINGS FOR I<sup>2</sup>C, AND SPI OPERATION

Upon bootup the device comes up in SPI mode. The following settings should be used for I<sup>2</sup>C, and SPI operation.

Register Field	I <sup>2</sup> C Driver Setting	SPI Driver Setting
I2C_SLEW_RATE (bits 5:3, register DRIVE_CONFIG, address 0x13, bank 0)	1	0
SPI_SLEW_RATE (bits 2:0, register DRIVE_CONFIG, address 0x13, bank 0)	1	5

### 12.4 NOTCH FILTER AND ANTI-ALIAS FILTER OPERATION

Use of Notch Filter and Anti-Alias Filter is supported only for Low Noise (LN) mode operation. The host is responsible for keeping the UI path in LN mode while Notch Filter and Anti-Alias filter are turned on.

### 12.5 INT\_ASYNC\_RESET CONFIGURATION

For register INT\_CONFIG1 (bank 0 register 0x64) bit 4 INT\_ASYNC\_RESET, user should change setting to 0 from default setting of 1, for proper INT1 pin operation.

### 12.6 GYROSCOPE ON/OFF PROCEDURE

To turn gyroscope on:

- Set bit 6 of register GYRO\_ON\_OFF\_CONFIG (bank 4, address 0x0E) to 1
- Set bits 3:2 of register PWR\_MGMT0 (bank 0, address 0x4E) to 11 to turn on gyroscope in Low Noise Mode

To turn gyroscope off:

- Set bits 3:2 of register PWR\_MGMT0 (bank 0, address 0x4E) to 00
- Set bit 6 of register GYRO\_ON\_OFF\_CONFIG (bank 4, address 0x0E) to 0

## 13 REGISTER MAP

This section lists the register map for the ICM-40607, for user banks 0, 1, 2, 4.

### 13.1 USER BANK 0 REGISTER MAP

Addr (Hex)	Addr (Dec.)	Register Name	Serial I/F	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
11	17	DEVICE_CONFIG	R/W	-			SPI_MODE	-			SOFT_RESET_CONFIG
13	19	DRIVE_CONFIG	R/W	-		I2C_SLEW_RATE			SPI_SLEW_RATE		
14	20	INT_CONFIG	R/W	-		INT2_MODE	INT2_DRIVE_CIRCUIT	INT2_POLARITY	INT1_MODE	INT1_DRIVE_CIRCUIT	INT1_POLARITY
16	22	FIFO_CONFIG	R/W	FIFO_MODE		-					
1D	29	TEMP_DATA1	SYNCR	TEMP_DATA[15:8]							
1E	30	TEMP_DATA0	SYNCR	TEMP_DATA[7:0]							
1F	31	ACCEL_DATA_X1	SYNCR	ACCEL_DATA_X[15:8]							
20	32	ACCEL_DATA_X0	SYNCR	ACCEL_DATA_X[7:0]							
21	33	ACCEL_DATA_Y1	SYNCR	ACCEL_DATA_Y[15:8]							
22	34	ACCEL_DATA_Y0	SYNCR	ACCEL_DATA_Y[7:0]							
23	35	ACCEL_DATA_Z1	SYNCR	ACCEL_DATA_Z[15:8]							
24	36	ACCEL_DATA_Z0	SYNCR	ACCEL_DATA_Z[7:0]							
25	37	GYRO_DATA_X1	SYNCR	GYRO_DATA_X[15:8]							
26	38	GYRO_DATA_X0	SYNCR	GYRO_DATA_X[7:0]							
27	39	GYRO_DATA_Y1	SYNCR	GYRO_DATA_Y[15:8]							
28	40	GYRO_DATA_Y0	SYNCR	GYRO_DATA_Y[7:0]							
29	41	GYRO_DATA_Z1	SYNCR	GYRO_DATA_Z[15:8]							
2A	42	GYRO_DATA_Z0	SYNCR	GYRO_DATA_Z[7:0]							
2B	43	TMST_FSYNCH	SYNCR	TMST_FSYNCH_DATA[15:8]							
2C	44	TMST_FSYNCL	SYNCR	TMST_FSYNCH_DATA[7:0]							
2D	45	INT_STATUS	R/C	INT_SYNC_INT	PLL_RDY_INT	RESET_DONE_INT	DATA_RDY_INT	FIFO_THS_INT	FIFO_FULL_INT	AGC_RDY_INT	
2E	46	FIFO_COUNTH	R	FIFO_COUNT[15:8]							
2F	47	FIFO_COUNTL	R	FIFO_COUNT[7:0]							
30	48	FIFO_DATA	R	FIFO_DATA							
31	49	APEX_DATA0	SYNCR	STEP_CNT[15:8]							
32	50	APEX_DATA1	SYNCR	STEP_CNT[7:0]							
33	51	APEX_DATA2	R	STEP_CADENCE							
34	52	APEX_DATA3	R	-					DMP_IDLE	ACTIVITY_CLASS	
35	53	APEX_DATA4	R	-			TAP_NUM		TAP_AXIS		TAP_DIR
36	54	APEX_DATA5	R	-		DOUBLE_TAP_TIMING					
37	55	INT_STATUS2	R/C	-				SMD_INT	WOM_Z_INT	WOM_Y_INT	WOM_X_INT
38	56	INT_STATUS3	R/C	-		STEP_DET_INT	STEP_CNT_OVERFLOW_INT	TILT_DET_INT	WAKE_INT	SLEEP_INT	TAP_DET_INT
4B	75	SIGNAL_PATH_RESET	W/C	-	DMP_INIT_EN	DMP_MEM_RESET_EN	-	ABORT_AND_RESET	TMST_STROBE	FIFO_FLUSH	-
4C	76	INTF_CONFIG0	R/W	FIFO_HOLD_LAST_DATA_EN	FIFO_COUNT_REC	FIFO_COUNT_ENDIAN	SENSOR_DATA_ENDIAN	-		UI_SIFS_CFG	
4D	77	INTF_CONFIG1	R/W	-				ACCEL_LP_CLK_SEL	-	CLKSEL	
4E	78	PWR_MGMT0	R/W	-		TEMP_DIS	IDLE	GYRO_MODE		ACCEL_MODE	
4F	79	GYRO_CONFIG0	R/W	GYRO_FS_SEL			-	GYRO_ODR			
50	80	ACCEL_CONFIG0	R/W	ACCEL_FS_SEL			-	ACCEL_ODR			
51	81	GYRO_CONFIG1	R/W	TEMP_FILT_BW			-	GYRO_UI_FILT_ORD		GYRO_DEC2_M2_ORD	
52	82	GYRO_ACCEL_CONFIG0	R/W	ACCEL_UI_FILT_BW				GYRO_UI_FILT_BW			
53	83	ACCEL_CONFIG1	R/W	-			ACCEL_UI_FILT_ORD		ACCEL_DEC2_M2_ORD		-

Addr (Hex)	Addr (Dec.)	Register Name	Serial I/F	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	
54	84	TMST_CONFIG	R/W	-			TMST_TO_REGS_EN	TMST_RES	TMST_DELTA_EN	TMST_FSYNC_EN	TMST_EN	
56	86	APEX_CONFIG0	R/W	DMP_POWER_SAVE	TAP_ENABLE	PED_ENABLE	TILT_ENABLE	R2W_EN	-	DMP_ODR		
57	87	SMD_CONFIG	R/W	-				WOM_INT_MODE	WOM_MODE	SMD_MODE		
5F	95	FIFO_CONFIG1	R/W	-	FIFO_RESUME_PARTIAL_READ	FIFO_WM_GTH	-	FIFO_TMST_FSYNC_EN	FIFO_TEMP_EN	FIFO_GYRO_EN	FIFO_ACCEL_EN	
60	96	FIFO_CONFIG2	R/W	FIFO_WM[7:0]								
61	97	FIFO_CONFIG3	R/W	-				FIFO_WM[11:8]				
62	98	FSYNC_CONFIG	R/W	-	FSYNC_UI_SEL			-		FSYNC_UI_FLAG_CLEAR_SEL	FSYNC_POLARITY	
63	99	INT_CONFIG0	R/W	-		UI_DRDY_INT_CLEAR		FIFO_THS_INT_CLEAR		FIFO_FULL_INT_CLEAR		
64	100	INT_CONFIG1	R/W	-	INT_TPULSE_DURATION	INT_TDEASSERT_DISABLE	INT_ASYNC_RESET	-				
65	101	INT_SOURCE0	R/W	-	UI_FSYNC_INT1_EN	PLL_RDY_INT1_EN	RESET_DONE_INT1_EN	UI_DRDY_INT1_EN	FIFO_THS_INT1_EN	FIFO_FULL_INT1_EN	UI_AGC_RDY_INT1_EN	
66	102	INT_SOURCE1	R/W	-				SMD_INT1_EN	WOM_Z_INT1_EN	WOM_Y_INT1_EN	WOM_X_INT1_EN	
68	104	INT_SOURCE3	R/W	-	UI_FSYNC_INT2_EN	PLL_RDY_INT2_EN	RESET_DONE_INT2_EN	UI_DRDY_INT2_EN	FIFO_THS_INT2_EN	FIFO_FULL_INT2_EN	UI_AGC_RDY_INT2_EN	
69	105	INT_SOURCE4	R/W	-				SMD_INT2_EN	WOM_Z_INT2_EN	WOM_Y_INT2_EN	WOM_X_INT2_EN	
6C	108	FIFO_LOST_PKT0	R	FIFO_LOST_PKT_CNT[1:8]								
6D	109	FIFO_LOST_PKT1	R	FIFO_LOST_PKT_CNT[7:0]								
70	112	SELF_TEST_CONFIG	R/W	-	ACCEL_STPOWER	EN_AZ_ST	EN_AY_ST	EN_AX_ST	EN_GZ_ST	EN_GY_ST	EN_GX_ST	
75	117	WHO_AM_I	R	WHO_AM_I								
76	118	REG_BANK_SEL	R/W	-							BANK_SEL	

### 13.2 USER BANK 1 REGISTER MAP

Addr (Hex)	Addr (Dec.)	Register Name	Serial I/F	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0		
03	03	SENSOR_CONFIG0	R/W	-		ZG_DISABLE	YG_DISABLE	XG_DISABLE	ZA_DISABLE	YA_DISABLE	XA_DISABLE		
0B	11	GYRO_CONFIG_STATIC2	R/W	-							GYRO_AAF_D IS	GYRO_NF_DI S	
0C	12	GYRO_CONFIG_STATIC3	R/W			GYRO_AAF_DELT							
0D	13	GYRO_CONFIG_STATIC4	R/W	GYRO_AAF_DELTSQR[7:0]									
0E	14	GYRO_CONFIG_STATIC5	R/W	GYRO_AAF_BITSHIFT						GYRO_AAF_DELTSQR[11:8]			
0F	15	GYRO_CONFIG_STATIC6	R/W	GYRO_X_NF_COSWZ[7:0]									
10	16	GYRO_CONFIG_STATIC7	R/W	GYRO_Y_NF_COSWZ[7:0]									
11	17	GYRO_CONFIG_STATIC8	R/W	GYRO_Z_NF_COSWZ[7:0]									
12	18	GYRO_CONFIG_STATIC9	R/W	-		GYRO_Z_NF_COSWZ_SEL[0]	GYRO_Y_NF_COSWZ_SEL[0]	GYRO_X_NF_COSWZ_SEL[0]	GYRO_Z_NF_COSWZ[8]	GYRO_Y_NF_COSWZ[8]	GYRO_X_NF_COSWZ[8]		
13	19	GYRO_CONFIG_STATIC10	R/W	-	GYRO_NF_BW_SEL				GYRO_HPF_BW_IND			GYRO_HPF_O RD_IND	
5F	95	XG_ST_DATA	R/W	XG_ST_DATA									
60	96	YG_ST_DATA	R/W	YG_ST_DATA									
61	97	ZG_ST_DATA	R/W	ZG_ST_DATA									
62	98	TMSTVAL0	R	TMST_VALUE[7:0]									
63	99	TMSTVAL1	R	TMST_VALUE[15:8]									
64	100	TMSTVAL2	R	-				TMST_VALUE[19:16]					
70	112	OTP_STATUS	R	-					OTP_DONE	-			
7A	122	INTF_CONFIG4	R/W	-								SPI_AP_4WIR E	-
7B	123	INTF_CONFIG5	R/W	-							PIN9_FUNCTION		-

### 13.3 USER BANK 2 REGISTER MAP

Addr (Hex)	Addr (Dec.)	Register Name	Serial I/F	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
03	03	ACCEL_CONFIG_STATIC2	R/W	-	ACCEL_AAF_DELT						ACCEL_AAF_DIS
04	04	ACCEL_CONFIG_STATIC3	R/W	ACCEL_AAF_DELTSQR[7:0]							
05	05	ACCEL_CONFIG_STATIC4	R/W	ACCEL_AAF_BITSHIFT				ACCEL_AAF_DELTSQR[11:8]			
3B	59	XA_ST_DATA	R/W	XA_ST_DATA							
3C	60	YA_ST_DATA	R/W	YA_ST_DATA							
3D	61	ZA_ST_DATA	R/W	ZA_ST_DATA							

### 13.4 USER BANK 4 REGISTER MAP

Addr (Hex)	Addr (Dec.)	Register Name	Serial I/F	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	
40	64	APEX_CONFIG1	R/W	LOW_ENERGY_AMP_TH_SEL				DMP_POWER_SAVE_TIME_SEL				
41	65	APEX_CONFIG2	R/W	PED_AMP_TH_SEL				PED_STEP_CNT_TH_SEL				
42	66	APEX_CONFIG3	R/W	PED_STEP_DET_TH_SEL			PED_SB_THIRTH_SEL			PED_HI_EN_TH_SEL		
43	67	APEX_CONFIG4	R/W	TILT_WAIT_TIME_SEL		SLEEP_TIME_OUT			-			
44	68	APEX_CONFIG5	R/W	-				MOUNTING_MATRIX				
45	69	APEX_CONFIG6	R/W	-				SLEEP_GESTURE_DELAY				
46	70	APEX_CONFIG7	R/W	TAP_MIN_JERK_TH							TAP_MAX_PEAK_TOL	
47	71	APEX_CONFIG8	R/W	-	TAP_TMAX		TAP_TAVG		TAP_TMIN			
4A	74	ACCEL_WOM_X_THR	R/W	WOM_X_TH								
4B	75	ACCEL_WOM_Y_THR	R/W	WOM_Y_TH								
4C	76	ACCEL_WOM_Z_THR	R/W	WOM_Z_TH								
4D	77	INT_SOURCE6	R/W	-	STEP_DET_INT1_EN	STEP_CNT_OVERFLOW_INT1_EN	TILT_DET_INT1_EN	-		TAP_DET_INT1_EN		
4E	78	INT_SOURCE7	R/W	-	STEP_DET_INT2_EN	STEP_CNT_OVERFLOW_INT2_EN	TILT_DET_INT2_EN	-		TAP_DET_INT2_EN		
77	119	OFFSET_USER0	R/W	GYRO_X_OFFUSER[7:0]								
78	120	OFFSET_USER1	R/W	GYRO_Y_OFFUSER[11:8]				GYRO_X_OFFUSER[11:8]				
79	121	OFFSET_USER2	R/W	GYRO_Y_OFFUSER[7:0]								
7A	122	OFFSET_USER3	R/W	GYRO_Z_OFFUSER[7:0]								
7B	123	OFFSET_USER4	R/W	ACCEL_X_OFFUSER[11:8]				GYRO_Z_OFFUSER[11:8]				
7C	124	OFFSET_USER5	R/W	ACCEL_X_OFFUSER[7:0]								
7D	125	OFFSET_USER6	R/W	ACCEL_Y_OFFUSER[7:0]								
7E	126	OFFSET_USER7	R/W	ACCEL_Z_OFFUSER[11:8]				ACCEL_Y_OFFUSER[11:8]				
7F	127	OFFSET_USER8	R/W	ACCEL_Z_OFFUSER[7:0]								

Detailed register descriptions are provided in the sections that follow. Please note the following regarding Clock Domain for each register:

1. Clock Domain: SCLK\_UI means that the register is controlled from the UI interface



## 14 USER BANK 0 REGISTER MAP – DESCRIPTIONS

This section describes the function and contents of each register within USR Bank 0.

**Note:** The device powers up in sleep mode.

### 14.1 DEVICE\_CONFIG

Name: DEVICE_CONFIG Address: 17 (11h) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:5	-	Reserved
4	SPI_MODE	SPI mode selection 0: Mode 0 and Mode 3 (default) 1: Mode 1 and Mode 2
3:1	-	Reserved
0	SOFT_RESET_CONFIG	Software reset configuration 0: Normal (default) 1: Enable reset

### 14.2 DRIVE\_CONFIG

Name: DRIVE_CONFIG Address: 19 (13h) Serial IF: R/W Reset value: 0x05 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	-	Reserved
5:3	I2C_SLEW_RATE	Controls slew rate for output pin 14 in I <sup>2</sup> C mode only 000: 20ns-60ns 001: 12ns-36ns 010: 6ns-18ns 011: 4ns-12ns 100: 2ns-6ns 101: < 2ns 110: Reserved 111: Reserved
2:0	SPI_SLEW_RATE	Controls slew rate for output pin 14 in SPI mode, and for all other output pins 000: 20ns-60ns 001: 12ns-36ns 010: 6ns-18ns 011: 4ns-12ns 100: 2ns-6ns 101: < 2ns 110: Reserved 111: Reserved

### 14.3 INT\_CONFIG

Name: INT_CONFIG Address: 20 (14h) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	-	Reserved
5	INT2_MODE	INT2 interrupt mode 0: Pulsed mode 1: Latched mode
4	INT2_DRIVE_CIRCUIT	INT2 drive circuit 0: Open drain 1: Push pull
3	INT2_POLARITY	INT2 interrupt polarity 0: Active low 1: Active high (default)
2	INT1_MODE	INT1 interrupt mode 0: Pulsed mode 1: Latched mode
1	INT1_DRIVE_CIRCUIT	INT1 drive circuit 0: Reserved (do not use) 1: Push pull
0	INT1_POLARITY	INT1 interrupt polarity 0: Active low 1: Active high (default)

### 14.4 FIFO\_CONFIG

Name: FIFO_CONFIG Address: 22 (16h) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	FIFO_MODE	00: Bypass Mode (default) 01: Stream-to-FIFO Mode 10: STOP-on-FULL Mode 11: STOP-on-FULL Mode
5:0	-	Reserved

### 14.5 TEMP\_DATA1

Name: TEMP_DATA1 Address: 29 (1Dh) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	TEMP_DATA[15:8]	Upper byte of temperature data

## 14.6 TEMP\_DATA0

Name: TEMP_DATA0 Address: 30 (1Eh) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	TEMP_DATA[7:0]	Lower byte of temperature data

Temperature data value from the sensor data registers can be converted to degrees centigrade by using the following formula:

$$\text{Temperature in Degrees Centigrade} = (\text{TEMP\_DATA} / 132.48) + 25$$

Temperature data stored in FIFO is an 8-bit quantity, FIFO\_TEMP\_DATA. It can be converted to degrees centigrade by using the following formula:

$$\text{Temperature in Degrees Centigrade} = (\text{FIFO\_TEMP\_DATA} / 2.07) + 25$$

## 14.7 ACCEL\_DATA\_X1

Name: ACCEL_DATA_X1 Address: 31 (1Fh) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ACCEL_DATA_X[15:8]	Upper byte of Accel X-axis data

## 14.8 ACCEL\_DATA\_X0

Name: ACCEL_DATA_X0 Address: 32 (20h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ACCEL_DATA_X[7:0]	Lower byte of Accel X-axis data

## 14.9 ACCEL\_DATA\_Y1

Name: ACCEL_DATA_Y1 Address: 33 (21h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ACCEL_DATA_Y[15:8]	Upper byte of Accel Y-axis data

#### 14.10 ACCEL\_DATA\_Y0

Name: ACCEL_DATA_Y0 Address: 34 (22h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ACCEL_DATA_Y[7:0]	Lower byte of Accel Y-axis data

#### 14.11 ACCEL\_DATA\_Z1

Name: ACCEL_DATA_Z1 Address: 35 (23h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ACCEL_DATA_Z[15:8]	Upper byte of Accel Z-axis data

#### 14.12 ACCEL\_DATA\_Z0

Name: ACCEL_DATA_Z0 Address: 36 (24h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ACCEL_DATA_Z[7:0]	Lower byte of Accel Z-axis data

#### 14.13 GYRO\_DATA\_X1

Name: GYRO_DATA_X1 Address: 37 (25h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_DATA_X[15:8]	Upper byte of Gyro X-axis data

#### 14.14 GYRO\_DATA\_X0

Name: GYRO_DATA_X0 Address: 38 (26h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_DATA_X[7:0]	Lower byte of Gyro X-axis data

#### 14.15 GYRO\_DATA\_Y1

Name: GYRO_DATA_Y1 Address: 39 (27h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_DATA_Y[15:8]	Upper byte of Gyro Y-axis data

#### 14.16 GYRO\_DATA\_Y0

Name: GYRO_DATA_Y0 Address: 40 (28h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_DATA_Y[7:0]	Lower byte of Gyro Y-axis data

#### 14.17 GYRO\_DATA\_Z1

Name: GYRO_DATA_Z1 Address: 41 (29h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_DATA_Z[15:8]	Upper byte of Gyro Z-axis data

#### 14.18 GYRO\_DATA\_Z0

Name: GYRO_DATA_Z0 Address: 42 (2Ah) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_DATA_Z[7:0]	Lower byte of Gyro Z-axis data

#### 14.19 TMST\_FSYNCH

Name: TMST_FSYNCH Address: 43 (2Bh) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	TMST_FSYNCH_DATA[15:8]	Stores the upper byte of the time delta from the rising edge of FSYNCH to the latest ODR until the UI Interface reads the FSYNCH tag in the status register

## 14.20 TMST\_FSYNCL

Name: TMST_FSYNCL Address: 44 (2Ch) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	TMST_FSYNC_DATA[7:0]	Stores the lower byte of the time delta from the rising edge of FSYNC to the latest ODR until the UI Interface reads the FSYNC tag in the status register

## 14.21 INT\_STATUS

Name: INT_STATUS Address: 45 (2Dh) Serial IF: R/C Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6	UI_FSYNC_INT	This bit automatically sets to 1 when a UI FSYNC interrupt is generated. The bit clears to 0 after the register has been read.
5	PLL_RDY_INT	This bit automatically sets to 1 when a PLL Ready interrupt is generated. The bit clears to 0 after the register has been read.
4	RESET_DONE_INT	This bit automatically sets to 1 when software reset is complete. The bit clears to 0 after the register has been read.
3	DATA_RDY_INT	This bit automatically sets to 1 when a Data Ready interrupt is generated. The bit clears to 0 after the register has been read.
2	FIFO_THS_INT	This bit automatically sets to 1 when the FIFO buffer reaches the threshold value. The bit clears to 0 after the register has been read.
1	FIFO_FULL_INT	This bit automatically sets to 1 when the FIFO buffer is full. The bit clears to 0 after the register has been read.
0	AGC_RDY_INT	This bit automatically sets to 1 when an AGC Ready interrupt is generated. The bit clears to 0 after the register has been read.

## 14.22 FIFO\_COUNTH

Name: FIFO_COUNTH Address: 46 (2Eh) Serial IF: R Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	FIFO_COUNT[15:8]	High Bits, count indicates the number of records or bytes available in FIFO according to FIFO_COUNT_REC setting. Note: Must read FIFO_COUNTL to latch new data for both FIFO_COUNTH and FIFO_COUNTL.

### 14.23 FIFO\_COUNTL

Name: FIFO_COUNTL Address: 47 (2Fh) Serial IF: R Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	FIFO_COUNT[7:0]	Low Bits, count indicates the number of records or bytes available in FIFO according to FIFO_COUNT_REC setting. Reading this byte latches the data for both FIFO_COUNTH, and FIFO_COUNTL.

### 14.24 FIFO\_DATA

Name: FIFO_DATA Address: 48 (30h) Serial IF: R Reset value: 0xFF Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	FIFO_DATA	FIFO data port

### 14.25 APEX\_DATA0

Name: APEX_DATA0 Address: 49 (31h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	STEP_CNT[7:0]	Pedometer Output: Lower byte of Step Count measured by pedometer

### 14.26 APEX\_DATA1

Name: APEX_DATA1 Address: 50 (32h) Serial IF: SYNCR Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	STEP_CNT[15:8]	Pedometer Output: Upper byte of Step Count measured by pedometer

## 14.27 APEX\_DATA2

Name: APEX_DATA2 Address: 51 (33h) Serial IF: R Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	STEP_CADENCE	Pedometer Output: Walk/run cadency in number of samples. Format is u6.2. e.g. At 50Hz ODR and 2Hz walk frequency, the cadency is 25 samples. The register will output 100.

## 14.28 APEX\_DATA3

Name: APEX_DATA3 Address: 52 (34h) Serial IF: R Reset value: 0x04 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:3	-	Reserved
2	DMP_IDLE	0: Indicates DMP is running 1: Indicates DMP is idle
1:0	ACTIVITY_CLASS	Pedometer Output: Detected activity 00: Unknown 01: Walk 10: Run 11: Reserved



## 14.29 APEX\_DATA4

Name: APEX_DATA4 Address: 53 (35h) Serial IF: R Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:5	-	Reserved
4:3	TAP_NUM	Tap Detection Output: Number of taps in the current Tap event 00: No tap 01: Single tap 10: Double tap 11: Reserved
2:1	TAP_AXIS	Tap Detection Output: Represents the accelerometer axis on which tap energy is concentrated 00: X-axis 01: Y-axis 10: Z-axis 11: Reserved
0	TAP_DIR	Tap Detection Output: Polarity of tap pulse 0: Current accelerometer value – Previous accelerometer value is a positive value 1: Current accelerometer value – Previous accelerometer value is a negative value or zero

## 14.30 APEX\_DATA5

Name: APEX_DATA5 Address: 54 (36h) Serial IF: R Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	-	Reserved
5:0	DOUBLE_TAP_TIMING	DOUBLE_TAP_TIMING measures the time interval between the two taps when double tap is detected. It counts every 16 accelerometer samples as one unit between the 2 tap pulses. Therefore, the value is related to the accelerometer ODR.  Time in seconds = DOUBLE_TAP_TIMING * 16 / ODR  For example, if the accelerometer ODR is 500 Hz, and the DOUBLE_TAP_TIMING register reading is 6, the time interval value is $6 * 16 / 500 = 0.192$ seconds.

### 14.31 INT\_STATUS2

Name: INT_STATUS2		
Address: 55 (37h)		
Serial IF: R/C		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	-	Reserved
3	SMD_INT	Significant Motion Detection Interrupt, clears on read
2	WOM_Z_INT	Wake on Motion Interrupt on Z-axis, clears on read
1	WOM_Y_INT	Wake on Motion Interrupt on Y-axis, clears on read
0	WOM_X_INT	Wake on Motion Interrupt on X-axis, clears on read

### 14.32 INT\_STATUS3

Name: INT_STATUS3		
Address: 56 (38h)		
Serial IF: R/C		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	-	Reserved
5	STEP_DET_INT	Step Detection Interrupt, clears on read
4	STEP_CNT_OVF_INT	Step Count Overflow Interrupt, clears on read
3	TILT_DET_INT	Tilt Detection Interrupt, clears on read
2	WAKE_INT	Wake Event Interrupt, clears on read
1	SLEEP_INT	Sleep Event Interrupt, clears on read
0	TAP_DET_INT	Tap Detection Interrupt, clears on read

### 14.33 SIGNAL\_PATH\_RESET

Name: SIGNAL_PATH_RESET		
Address: 75 (4Bh)		
Serial IF: W/C		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6	DMP_INIT_EN	When this bit is set to 1, the DMP is enabled
5	DMP_MEM_RESET_EN	When this bit is set to 1, the DMP memory is reset
4	-	Reserved
3	ABORT_AND_RESET	When this bit is set to 1, the signal path is reset by restarting the ODR counter and signal path controls
2	TMST_STROBE	When this bit is set to 1, the time stamp counter is latched into the time stamp register. This is a write on clear bit.
1	FIFO_FLUSH	When set to 1, FIFO will get flushed.
0	-	Reserved

### 14.34 INTF\_CONFIG0

Name: INTF_CONFIG0 Address: 76 (4Ch) Serial IF: R/W Reset value: 0x30 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	FIFO_HOLD_LAST_DATA_EN	0: If Accel and Gyro ODRs are different, decimal value -32768 will be written to FIFO for the sensor with lower ODR until new sensor data is available 1: If Accel and Gyro ODRs are different, last valid data is rewritten to FIFO for the sensor with lower ODR until new sensor data is available
6	FIFO_COUNT_REC	0: FIFO count is reported in bytes 1: FIFO count is reported in records (1 record = 16 bytes for header + gyro + accel + temp sensor data + time stamp, or 8 bytes for header + gyro/accel + temp sensor data)
5	FIFO_COUNT_ENDIAN	0: FIFO count is reported in Little Endian format 1: FIFO count is reported in Big Endian format (default)
4	SENSOR_DATA_ENDIAN	0: Sensor data is reported in Little Endian format 1: Sensor data is reported in Big Endian format (default)
3:2	-	Reserved
1:0	UI_SIFS_CFG	0x: Reserved 10: Disable SPI 11: Disable I2C

### 14.35 INTF\_CONFIG1

Name: INTF_CONFIG1 Address: 77 (4Dh) Serial IF: R/W Reset value: 0x91 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	-	Reserved
3	ACCEL_LP_CLK_SEL	0: Accelerometer LP mode uses Wake Up oscillator clock 1: Accelerometer LP mode uses RC oscillator clock
2	-	Reserved
1:0	CLKSEL	00: Always select internal RC oscillator 01: Select PLL when available, else select RC oscillator (default) 10: Reserved 11: Disable all clocks

**14.36 PWR\_MGMT0**

Name: PWR_MGMT0 Address: 78 (4Eh) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	-	Reserved
5	TEMP_DIS	0: Temperature sensor is enabled (default) 1: Temperature sensor is disabled
4	IDLE	If this bit is set to 1, the RC oscillator is powered on even if Accel and Gyro are powered off. Nominally this bit is set to 0, so when Accel and Gyro are powered off, the chip will go to OFF state, since the RC oscillator will also be powered off
3:2	GYRO_MODE	00: Turns gyroscope off (default) 01: Places gyroscope in Standby Mode 10: Reserved 11: Places gyroscope in Low Noise (LN) Mode  Gyroscope needs to be kept ON for a minimum of 45ms. When transitioning from OFF to any of the other modes, do not issue any register writes for 200µs.
1:0	ACCEL_MODE	00: Turns accelerometer off (default) 01: Turns accelerometer off 10: Places accelerometer in Low Power (LP) Mode 11: Places accelerometer in Low Noise (LN) Mode  When transitioning from OFF to any of the other modes, do not issue any register writes for 200µs.

**14.37 GYRO\_CONFIG0**

Name: GYRO\_CONFIG0  
 Address: 79 (4Fh)  
 Serial IF: R/W  
 Reset value: 0x06  
 Clock Domain: SCLK\_UI

BIT	NAME	FUNCTION
7:5	GYRO_FS_SEL	Full scale select for gyroscope UI interface output 000: $\pm 2000$ dps (default) 001: $\pm 1000$ dps 010: $\pm 500$ dps 011: $\pm 250$ dps 100: $\pm 125$ dps 101: $\pm 62.5$ dps 110: $\pm 31.25$ dps 111: $\pm 15.625$ dps
4	-	Reserved
3:0	GYRO_ODR	Gyroscope ODR selection for UI interface output 0000: Reserved 0001: Reserved 0010: Reserved 0011: 8kHz 0100: 4kHz 0101: 2kHz 0110: 1kHz 0111: 200Hz 1000: 100Hz 1001: 50Hz 1010: 25Hz 1011: 12.5Hz 1100: Reserved 1101: Reserved 1110: Reserved 1111: 50Hz

**14.38 ACCEL\_CONFIG0**

Name: ACCEL_CONFIG0 Address: 80 (50h) Serial IF: R/W Reset value: 0x06 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:5	ACCEL_FS_SEL	Full scale select for accelerometer UI interface output 000: $\pm 16g$ (default) 001: $\pm 8g$ 010: $\pm 4g$ 011: $\pm 2g$ 100: Reserved 101: Reserved 110: Reserved 111: Reserved
4	-	Reserved
3:0	ACCEL_ODR	Accelerometer ODR selection for UI interface output 0000: Reserved 0001: Reserved 0010: Reserved 0011: 8kHz (LN mode) 0100: 4kHz (LN mode) 0101: 2kHz (LN mode) 0110: 1kHz (LN mode) 0111: 200Hz (LP or LN mode) 1000: 100Hz (LP or LN mode) 1001: 50Hz (LP or LN mode) 1010: 25Hz (LP or LN mode) 1011: 12.5Hz (LP or LN mode) 1100: 6.25Hz (LP mode) 1101: 3.125Hz (LP mode) 1110: 1.5625Hz (LP mode) 1111: 50Hz (LP or LN mode)

**14.39 GYRO\_CONFIG1**

Name: GYRO_CONFIG1 Address: 81 (51h) Serial IF: R/W Reset value: 0x16 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:5	TEMP_FILT_BW	Sets the bandwidth of the temperature signal DLPF 000: DLPF BW = 4000Hz; DLPF Latency = 0.125ms (default) 001: DLPF BW = 170Hz; DLPF Latency = 1ms 010: DLPF BW = 82Hz; DLPF Latency = 2ms 011: DLPF BW = 40Hz; DLPF Latency = 4ms 100: DLPF BW = 20Hz; DLPF Latency = 8ms 101: DLPF BW = 10Hz; DLPF Latency = 16ms 110: DLPF BW = 5Hz; DLPF Latency = 32ms 111: DLPF BW = 5Hz; DLPF Latency = 32ms
4	-	Reserved
3:2	GYRO_UI_FILT_ORD	Selects order of GYRO UI FIR filter 00: 1 <sup>st</sup> Order 01: 2 <sup>nd</sup> Order 10: 3 <sup>rd</sup> Order 11: Reserved
1:0	GYRO_DEC2_M2_ORD	Selects order of GYRO DEC2_M2 filter 00: 1 <sup>st</sup> Order 01: 2 <sup>nd</sup> Order 10: 3 <sup>rd</sup> Order 11: Reserved

**14.40 GYRO\_ACCEL\_CONFIG0**

Name: GYRO\_ACCEL\_CONFIG0

Address: 82 (52h)

Serial IF: R/W

Reset value: 0x11

Clock Domain: SCLK\_UI

BIT	NAME	FUNCTION
7:4	ACCEL_UI_FILT_BW	<b>LN Mode:</b> Bandwidth for Accel LPF 0 BW=ODR/2 1 BW=max(400Hz, ODR)/4 (default) 2 BW=max(400Hz, ODR)/5 3 BW=max(400Hz, ODR)/8 4 BW=max(400Hz, ODR)/10 5 BW=max(400Hz, ODR)/16 6 BW=max(400Hz, ODR)/20 7 BW=max(400Hz, ODR)/40 8 to 13: Reserved 14 Low Latency option: Trivial decimation @ ODR of Dec2 filter output. Dec2 runs at max(400Hz, ODR) 15 Low Latency option: Trivial decimation @ ODR of Dec2 filter output. Dec2 runs at max(200Hz, 8*ODR)  <b>LP Mode:</b> 0 Reserved 1 1x AVG filter (default) 2 to 5 Reserved 6 16x AVG filter 7 to 15 Reserved
3:0	GYRO_UI_FILT_BW	<b>LN Mode:</b> Bandwidth for Gyro LPF 0 BW=ODR/2 1 BW=max(400Hz, ODR)/4 (default) 2 BW=max(400Hz, ODR)/5 3 BW=max(400Hz, ODR)/8 4 BW=max(400Hz, ODR)/10 5 BW=max(400Hz, ODR)/16 6 BW=max(400Hz, ODR)/20 7 BW=max(400Hz, ODR)/40 8 to 13: Reserved 14 Low Latency option: Trivial decimation @ ODR of Dec2 filter output. Dec2 runs at max(400Hz, ODR) 15 Low Latency option: Trivial decimation @ ODR of Dec2 filter output. Dec2 runs at max(200Hz, 8*ODR)



#### 14.41 ACCEL\_CONFIG1

Name: ACCEL_CONFIG1 Address: 83 (53h) Serial IF: R/W Reset value: 0x0D Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:5	-	Reserved
4:3	ACCEL_UI_FILT_ORD	Selects order of ACCEL UI FIR filter 00: 1 <sup>st</sup> Order 01: 2 <sup>nd</sup> Order 10: 3 <sup>rd</sup> Order 11: Reserved
2:1	ACCEL_DEC2_M2_ORD	Order of Accelerometer DEC2_M2 filter 00: 1 <sup>st</sup> order 01: 2 <sup>nd</sup> order 10: 3 <sup>rd</sup> order 11: Reserved
0	-	Reserved

#### 14.42 TMST\_CONFIG

Name: TMST_CONFIG Address: 84 (54h) Serial IF: R/W Reset value: 0x23 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:5	-	Reserved
4	TMST_TO_REGS_EN	0: TMST_VALUE[19:0] read always returns 0s 1: TMST_VALUE[19:0] read returns timestamp value
3	TMST_RES	Time Stamp resolution: When set to 0 (default), time stamp resolution is 1 $\mu$ s. When set to 1, resolution is 16 $\mu$ s
2	TMST_DELTA_EN	Time Stamp delta enable: When set to 1, the time stamp field contains the measurement of time since the last occurrence of ODR.
1	TMST_FSYNC_EN	Time Stamp register FSYNC enable (default). When set to 1, the contents of the Timestamp feature of FSYNC is enabled. The user also needs to select FIFO_TMST_FSYNC_EN in order to propagate the timestamp value to the FIFO.
0	TMST_EN	0: Time Stamp register disable 1: Time Stamp register enable (default)

#### 14.43 APEX\_CONFIG0

Name: APEX_CONFIG0 Address: 86 (56h) Serial IF: R/W Reset value: 0x82 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	DMP_POWER_SAVE	0: DMP power save mode not active 1: DMP power save mode active (default)
6	TAP_ENABLE	0: Tap Detection not enabled 1: Tap Detection enabled when accelerometer ODR is set to one of the ODR values supported by Tap Detection (200Hz, 500Hz, 1kHz)
5	PED_ENABLE	0: Pedometer not enabled 1: Pedometer enabled
4	TILT_ENABLE	0: Tilt Detection not enabled 1: Tilt Detection enabled
3	R2W_EN	0: Raise to Wake/Sleep not enabled 1: Raise to Wake/Sleep enabled
2	-	Reserved
1:0	DMP_ODR	00: 25Hz 01: Reserved 10: 50Hz 11: Reserved

#### 14.44 SMD\_CONFIG

Name: SMD_CONFIG Address: 87 (57h) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	-	Reserved
3	WOM_INT_MODE	0: Set WoM interrupt on the OR of all enabled accelerometer thresholds 1: Set WoM interrupt on the AND of all enabled accelerometer threshold
2	WOM_MODE	0: Initial sample is stored. Future samples are compared to initial sample 1: Compare current sample to previous sample
1:0	SMD_MODE	00: SMD disabled 01: WOM mode 10: SMD short (1 sec wait) An SMD event is detected when two WOM are detected 1 sec apart 11: SMD long (3 sec wait) An SMD event is detected when two WOM are detected 3 sec apart

#### 14.45 FIFO\_CONFIG1

Name: FIFO_CONFIG1 Address: 95 (5Fh) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6	FIFO_RESUME_PARTIAL_RD	0: Partial FIFO read disabled, requires re-reading of the entire FIFO 1: FIFO read can be partial, and resume from last read point
5	FIFO_WM_GT_TH	Trigger FIFO watermark interrupt on every ODR (DMA write) if $FIFO\_COUNT \geq FIFO\_WM\_TH$
4	-	Reserved
3	FIFO_TMST_FSYNC_EN	Must be set to 1 for all use cases
2	FIFO_TEMP_EN	Enable temperature sensor packets to go to FIFO
1	FIFO_GYRO_EN	Enable gyroscope packets to go to FIFO
0	FIFO_ACCEL_EN	Enable accelerometer packets to go to FIFO

#### 14.46 FIFO\_CONFIG2

Name: FIFO_CONFIG2 Address: 96 (60h) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	FIFO_WM[7:0]	Lower bits of FIFO watermark. Generate interrupt when the FIFO reaches or exceeds FIFO_WM size in bytes or records according to FIFO_COUNT_REC setting. FIFO_WM_EN must be zero before writing this register. Interrupt only fires once. This register should be set to non-zero value, before choosing this interrupt source.

#### 14.47 FIFO\_CONFIG3

Name: FIFO_CONFIG3 Address: 97 (61h) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	-	Reserved
3:0	FIFO_WM[11:8]	Upper bits of FIFO watermark. Generate interrupt when the FIFO reaches or exceeds FIFO_WM size in bytes or records according to FIFO_COUNT_REC setting. FIFO_WM_EN must be zero before writing this register. Interrupt only fires once. This register should be set to non-zero value, before choosing this interrupt source.

Note: Do not set FIFO\_WM to value 0.

#### 14.48 FSYNC\_CONFIG

Name: FSYNC_CONFIG Address: 98 (62h) Serial IF: R/W Reset value: 0x10 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6:4	FSYNC_UI_SEL	000: Do not tag FSYNC flag 001: Tag FSYNC flag to TEMP_OUT LSB 010: Tag FSYNC flag to GYRO_XOUT LSB 011: Tag FSYNC flag to GYRO_YOUT LSB 100: Tag FSYNC flag to GYRO_ZOUT LSB 101: Tag FSYNC flag to ACCEL_XOUT LSB 110: Tag FSYNC flag to ACCEL_YOUT LSB 111: Tag FSYNC flag to ACCEL_ZOUT LSB
3:2	-	Reserved
1	FSYNC_UI_FLAG_CLEAR_SEL	0: FSYNC flag is cleared when UI sensor register is updated 1: FSYNC flag is cleared when UI interface reads the sensor register LSB of FSYNC tagged axis
0	FSYNC_POLARITY	0: Start from Rising edge of FSYNC pulse to measure FSYNC interval 1: Start from Falling edge of FSYNC pulse to measure FSYNC interval

#### 14.49 INT\_CONFIG0

Name: INT_CONFIG0 Address: 99 (63h) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	-	Reserved
5:4	UI_DRDY_INT_CLEAR	Data Ready Interrupt Clear Option (latched mode) 00: Clear on Status Bit Read (default) 01: Clear on Status Bit Read 10: Clear on FIFO data 1Byte Read 11: Clear on Status Bit Read AND on FIFO data 1 byte read
3:2	FIFO_THS_INT_CLEAR	FIFO Threshold Interrupt Clear Option (latched mode) 00: Clear on Status Bit Read (default) 01: Clear on Status Bit Read 10: Clear on FIFO data 1Byte Read 11: Clear on Status Bit Read AND on FIFO data 1 byte read
1:0	FIFO_FULL_INT_CLEAR	FIFO Full Interrupt Clear Option (latched mode) 00: Clear on Status Bit Read (default) 01: Clear on Status Bit Read 10: Clear on FIFO data 1Byte Read 11: Clear on Status Bit Read AND on FIFO data 1 byte read

## 14.50 INT\_CONFIG1

Name: INT_CONFIG1 Address: 100 (64h) Serial IF: R/W Reset value: 0x10 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6	INT_TPULSE_DURATION	Interrupt pulse duration 0: Interrupt pulse duration is 100µs. Use only if ODR < 4kHz. (Default) 1: Interrupt pulse duration is 8 µs. Required if ODR ≥ 4kHz, optional for ODR < 4kHz.
5	INT_TDEASSERT_DISABLE	Interrupt de-assertion duration 0: The interrupt de-assertion duration is set to a minimum of 100µs. Use only if ODR < 4kHz. (Default) 1: Disables de-assert duration. Required if ODR ≥ 4kHz, optional for ODR < 4kHz.
4	INT_ASYNC_RESET	User should change setting to 0 from default setting of 1, for proper INT1 pin operation
3:0	-	Reserved

## 14.51 INT\_SOURCE0

Name: INT_SOURCE0 Address: 101 (65h) Serial IF: R/W Reset value: 0x10 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6	UI_FSYNC_INT1_EN	0: UI FSYNC interrupt not routed to INT1 1: UI FSYNC interrupt routed to INT1
5	PLL_RDY_INT1_EN	0: PLL ready interrupt not routed to INT1 1: PLL ready interrupt routed to INT1
4	RESET_DONE_INT1_EN	0: Reset done interrupt not routed to INT1 1: Reset done interrupt routed to INT1
3	UI_DRDY_INT1_EN	0: UI data ready interrupt not routed to INT1 1: UI data ready interrupt routed to INT1
2	FIFO_THS_INT1_EN	0: FIFO threshold interrupt not routed to INT1 1: FIFO threshold interrupt routed to INT1
1	FIFO_FULL_INT1_EN	0: FIFO full interrupt not routed to INT1 1: FIFO full interrupt routed to INT1
0	UI_AGC_RDY_INT1_EN	0: UI AGC ready interrupt not routed to INT1 1: UI AGC ready interrupt routed to INT1

## 14.52 INT\_SOURCE1

Name: INT_SOURCE1		
Address: 102 (66h)		
Serial IF: R/W		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	-	Reserved
3	SMD_INT1_EN	0: SMD interrupt not routed to INT1 1: SMD interrupt routed to INT1
2	WOM_Z_INT1_EN	0: Z-axis WOM interrupt not routed to INT1 1: Z-axis WOM interrupt routed to INT1
1	WOM_Y_INT1_EN	0: Y-axis WOM interrupt not routed to INT1 1: Y-axis WOM interrupt routed to INT1
0	WOM_X_INT1_EN	0: X-axis WOM interrupt not routed to INT1 1: X-axis WOM interrupt routed to INT1

## 14.53 INT\_SOURCE3

Name: INT_SOURCE3		
Address: 104 (68h)		
Serial IF: R/W		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6	UI_FSYNC_INT2_EN	0: UI FSYNC interrupt not routed to INT2 1: UI FSYNC interrupt routed to INT2
5	PLL_RDY_INT2_EN	0: PLL ready interrupt not routed to INT2 1: PLL ready interrupt routed to INT2
4	RESET_DONE_INT2_EN	0: Reset done interrupt not routed to INT2 1: Reset done interrupt routed to INT2
3	UI_DRDY_INT2_EN	0: UI data ready interrupt not routed to INT2 1: UI data ready interrupt routed to INT2
2	FIFO_THS_INT2_EN	0: FIFO threshold interrupt not routed to INT2 1: FIFO threshold interrupt routed to INT2
1	FIFO_FULL_INT2_EN	0: FIFO full interrupt not routed to INT2 1: FIFO full interrupt routed to INT2
0	UI_AGC_RDY_INT2_EN	0: UI AGC ready interrupt not routed to INT2 1: UI AGC ready interrupt routed to INT2

#### 14.54 INT\_SOURCE4

Name: INT_SOURCE4 Address: 105 (69h) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	-	Reserved
3	SMD_INT2_EN	0: SMD interrupt not routed to INT2 1: SMD interrupt routed to INT2
2	WOM_Z_INT2_EN	0: Z-axis WOM interrupt not routed to INT2 1: Z-axis WOM interrupt routed to INT2
1	WOM_Y_INT2_EN	0: Y-axis WOM interrupt not routed to INT2 1: Y-axis WOM interrupt routed to INT2
0	WOM_X_INT2_EN	0: X-axis WOM interrupt not routed to INT2 1: X-axis WOM interrupt routed to INT2

#### 14.55 FIFO\_LOST\_PKT0

Name: FIFO_LOST_PKT0 Address: 108 (6Ch) Serial IF: R Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	FIFO_LOST_PKT_CNT[7:0]	Low byte, number of packets lost in the FIFO

#### 14.56 FIFO\_LOST\_PKT1

Name: FIFO_LOST_PKT1 Address: 109 (6Dh) Serial IF: R Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	FIFO_LOST_PKT_CNT[15:8]	High byte, number of packets lost in the FIFO

## 14.57 SELF\_TEST\_CONFIG

Name: SELF_TEST_CONFIG		
Address: 112 (70h)		
Serial IF: R/W		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6	ACCEL_ST_POWER	Set to 1 for accel self-test Otherwise set to 0; Set to 0 after self-test is completed
5	EN_AZ_ST	Enable Z-accel self-test
4	EN_AY_ST	Enable Y-accel self-test
3	EN_AX_ST	Enable X-accel self-test
2	EN_GZ_ST	Enable Z-gyro self-test
1	EN_GY_ST	Enable Y-gyro self-test
0	EN_GX_ST	Enable X-gyro self-test

## 14.58 WHO\_AM\_I

Name: WHO_AM_I		
Address: 117 (75h)		
Serial IF: R		
Reset value: 0x38		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	WHOAMI	Register to indicate to user which device is being accessed

### Description:

This register is used to verify the identity of the device. The contents of WHOAMI is an 8-bit device ID. The default value of the register is 0x38. This is different from the I<sup>2</sup>C address of the device as seen on the slave I<sup>2</sup>C controller by the applications processor.

## 14.59 REG\_BANK\_SEL

Note: This register is accessible from all register banks

Name: REG_BANK_SEL		
Address: 118 (76h)		
Serial IF: R/W		
Reset value: 0x00		
Clock Domain: ALL		
BIT	NAME	FUNCTION
7:3	-	Reserved
2:0	BANK_SEL	Register bank selection 000: Bank 0 (default) 001: Bank 1 010: Bank 2 011: Bank 3 100: Bank 4 101: Reserved 110: Reserved 111: Reserved



## 15 USER BANK 1 REGISTER MAP – DESCRIPTIONS

This section describes the function and contents of each register within USR Bank 1.

### 15.1 SENSOR\_CONFIG0

Name: SENSOR_CONFIG0 Address: 03 (03h) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	-	Reserved
5	ZG_DISABLE	0: Z gyroscope is on 1: Z gyroscope is disabled
4	YG_DISABLE	0: Y gyroscope is on 1: Y gyroscope is disabled
3	XG_DISABLE	0: X gyroscope is on 1: X gyroscope is disabled
2	ZA_DISABLE	0: Z accelerometer is on 1: Z accelerometer is disabled
1	YA_DISABLE	0: Y accelerometer is on 1: Y accelerometer is disabled
0	XA_DISABLE	0: X accelerometer is on 1: X accelerometer is disabled

### 15.2 GYRO\_CONFIG\_STATIC2

Name: GYRO_CONFIG_STATIC2 Address: 11 (0Bh) Serial IF: R/W Reset value: 0xA8 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:2	-	Reserved
1	GYRO_AAF_DIS	0: Enable Anti-Aliasing/Low Pass Filter 1: Disable Anti-Aliasing/Low Pass Filter (default)
0	GYRO_NF_DIS	0: Enable Notch Filter 1: Disable Notch Filter (default)

### 15.3 GYRO\_CONFIG\_STATIC3

Name: GYRO_CONFIG_STATIC3 Address: 12 (0Ch) Serial IF: R/W Reset value: 0x3F Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	-	Reserved
5:0	GYRO_AAF_DELT	Controls bandwidth of the gyroscope anti-alias filter See section 5.2 for details

#### 15.4 GYRO\_CONFIG\_STATIC4

Name: GYRO_CONFIG_STATIC4 Address: 13 (0Dh) Serial IF: R/W Reset value: 0x80 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_AAF_DELTSQR[7:0]	Controls bandwidth of the gyroscope anti-alias filter See section 5.2 for details

#### 15.5 GYRO\_CONFIG\_STATIC5

Name: GYRO_CONFIG_STATIC5 Address: 14 (0Eh) Serial IF: R/W Reset value: 0x3F Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	GYRO_AAF_BITSHIFT	Controls bandwidth of the gyroscope anti-alias filter See section 5.2 for details
3:0	GYRO_AAF_DELTSQR[11:8]	Controls bandwidth of the gyroscope anti-alias filter See section 5.2 for details

#### 15.6 GYRO\_CONFIG\_STATIC6

Name: GYRO_CONFIG_STATIC6 Address: 15 (0Fh) Serial IF: R/W Reset value: 0x60 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_X_NF_COSWZ[7:0]	Used for gyroscope X-axis notch filter frequency selection See section 5.1 for details

#### 15.7 GYRO\_CONFIG\_STATIC7

Name: GYRO_CONFIG_STATIC7 Address: 16 (10h) Serial IF: R/W Reset value: 0x96 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_Y_NF_COSWZ[7:0]	Used for gyroscope Y-axis notch filter frequency selection See section 5.1 for details

## 15.8 GYRO\_CONFIG\_STATIC8

Name: GYRO_CONFIG_STATIC8		
Address: 17 (11h)		
Serial IF: R/W		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_Z_NF_COSWZ[7:0]	Used for gyroscope Z-axis notch filter frequency selection See section 5.1 for details

## 15.9 GYRO\_CONFIG\_STATIC9

Name: GYRO_CONFIG_STATIC9		
Address: 18 (12h)		
Serial IF: R/W		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	-	Reserved
5	GYRO_Z_NF_COSWZ_SEL[0]	Used for gyroscope Z-axis notch filter frequency selection See section 5.1 for details
4	GYRO_Y_NF_COSWZ_SEL[0]	Used for gyroscope Y-axis notch filter frequency selection See section 5.1 for details
3	GYRO_X_NF_COSWZ_SEL[0]	Used for gyroscope X-axis notch filter frequency selection See section 5.1 for details
2	GYRO_Z_NF_COSWZ[8]	Used for gyroscope Z-axis notch filter frequency selection See section 5.1 for details
1	GYRO_Y_NF_COSWZ[8]	Used for gyroscope Y-axis notch filter frequency selection See section 5.1 for details
0	GYRO_X_NF_COSWZ[8]	Used for gyroscope X-axis notch filter frequency selection See section 5.1 for details

## 15.10 GYRO\_CONFIG\_STATIC10

Name: GYRO_CONFIG_STATIC10		
Address: 19 (13h)		
Serial IF: R/W		
Reset value: 0x11		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6:4	GYRO_NF_BW_SEL	Selects bandwidth for gyroscope notch filter See section 5.1 for details
3:1	GYRO_HPF_BW_IND	Selects HPF 3dB cutoff frequency bandwidth See section 5.6 for details
0	GYRO_HPF_ORD_IND	Selects HPF filter order (see section 5.6 for details) 0: 1 <sup>st</sup> order HPF 1: 2 <sup>nd</sup> order HPF

### 15.11 XG\_ST\_DATA

Name: XG_ST_DATA		
Address: 95 (5Fh)		
Serial IF: R/W		
Reset value: 0xXX (The value in this register indicates the self-test output generated during manufacturing tests)		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	XG_ST_DATA	X-gyro self-test data

### 15.12 YG\_ST\_DATA

Name: YG_ST_DATA		
Address: 96 (60h)		
Serial IF: R/W		
Reset value: 0xXX (The value in this register indicates the self-test output generated during manufacturing tests)		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	YG_ST_DATA	Y-gyro self-test data

### 15.13 ZG\_ST\_DATA

Name: ZG_ST_DATA		
Address: 97 (61h)		
Serial IF: R/W		
Reset value: 0xXX (The value in this register indicates the self-test output generated during manufacturing tests)		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ZG_ST_DATA	Z-gyro self-test data

### 15.14 TMSTVAL0

Name: TMSTVAL0		
Address: 98 (62h)		
Serial IF: R		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	TMST_VALUE[7:0]	When TMST_STROBE is programmed, the current value of the internal counter is latched to this register. Allows the full 20-bit precision of the time stamp to be read back.

### 15.15 TMSTVAL1

Name: TMSTVAL1 Address: 99 (63h) Serial IF: R Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	TMST_VALUE[15:8]	When TMST_STROBE is programmed, the current value of the internal counter is latched to this register. Allows the full 20-bit precision of the time stamp to be read back.

### 15.16 TMSTVAL2

Name: TMSTVAL2 Address: 100 (64h) Serial IF: R Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	-	Reserved
3:0	TMST_VALUE[19:16]	When TMST_STROBE is programmed, the current value of the internal counter is latched to this register. Allows the full 20-bit precision of the time stamp to be read back.

### 15.17 OTP\_STATUS

Name: OTP_STATUS Address: 112 (70h) Serial IF: R Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:5	-	Reserved
4	OTP_DONE	This is a status bit that indicates when OTP loading is finished. This bit automatically sets to 1 when OTP loading is finished. The bit clears to 0 while OTP is being loaded.
3:0	-	Reserved

### 15.18 INTF\_CONFIG4

Name: INTF_CONFIG4 Address: 122 (7Ah) Serial IF: R/W Reset value: 0x03 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:2	-	Reserved
1	SPI_AP_4WIRE	0: AP interface uses 3-wire SPI mode 1: AP interface uses 4-wire SPI mode (default)
0	-	Reserved

**15.19 INTF\_CONFIG5**

Name: INTF_CONFIG5 Address: 123 (7Bh) Serial IF: R/W Reset value: 0x20 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:3	-	Reserved
2:1	PIN9_FUNCTION	Selects among the following functionalities for pin 9 00: INT2 01: FSYNC 10: Reserved 11: Reserved
0	-	Reserved

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## 16 USER BANK 2 REGISTER MAP – DESCRIPTIONS

This section describes the function and contents of each register within USR Bank 2.

### 16.1 ACCEL\_CONFIG\_STATIC2

Name: ACCEL_CONFIG_STATIC2 Address: 03 (03h) Serial IF: R/W Reset value: 0x7E Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6:1	ACCEL_AAF_DELT	Controls bandwidth of the accelerometer anti-alias filter See section 5.2 for details
0	ACCEL_AAF_DIS	0: Enable accelerometer anti-aliasing filter 1: Disable accelerometer anti-aliasing filter (default)

### 16.2 ACCEL\_CONFIG\_STATIC3

Name: ACCEL_CONFIG_STATIC3 Address: 04 (04h) Serial IF: R/W Reset value: 0x80 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ACCEL_AAF_DELTSQR[7:0]	Controls band width of the accelerometer anti-alias filter See section 5.2 for details

### 16.3 ACCEL\_CONFIG\_STATIC4

Name: ACCEL_CONFIG_STATIC4 Address: 05 (05h) Serial IF: R/W Reset value: 0x3F Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	ACCEL_AAF_BITSHIFT	Controls bandwidth of the accelerometer anti-alias filter See section 5.2 for details
3:0	ACCEL_AAF_DELTSQR[11:8]	Controls bandwidth of the accelerometer anti-alias filter See section 5.2 for details

### 16.4 XA\_ST\_DATA

Name: XA_ST_DATA Address: 59 (3Bh) Serial IF: R/W Reset value: 0xXX (The value in this register indicates the self-test output generated during manufacturing tests) Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	XA_ST_DATA	X-accel self-test data

## 16.5 YA\_ST\_DATA

Name: YA_ST_DATA		
Address: 60 (3Ch)		
Serial IF: R/W		
Reset value: 0xXX (The value in this register indicates the self-test output generated during manufacturing tests)		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	YA_ST_DATA	Y-accel self-test data

## 16.6 ZA\_ST\_DATA

Name: ZA_ST_DATA		
Address: 61 (3Dh)		
Serial IF: R/W		
Reset value: 0xXX (The value in this register indicates the self-test output generated during manufacturing tests)		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ZA_ST_DATA	Z-accel self-test data

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## 17 USER BANK 4 REGISTER MAP – DESCRIPTIONS

This section describes the function and contents of each register within USR Bank 4.

### 17.1 GYRO\_ON\_OFF\_CONFIG

Name: GYRO_ON_OFF_CONFIG Address: 14 (0Eh) Serial IF: R/W Reset value: 0x40 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6	GYRO_ON_OFF_CONFIG	Set value to 0 when turning off gyroscope. Set value to 1 when turning on gyroscope. See Section 12 for details.
5:0	-	Reserved

### 17.2 APEX\_CONFIG1

Name: APEX_CONFIG1 Address: 64 (40h) Serial IF: R/W Reset value: 0xA2 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	LOW_ENERGY_AMP_TH_SEL	Pedometer Low Energy mode amplitude threshold selection Use default value 1010b
3:0	DMP_POWER_SAVE_TIME_SEL	<p>When the DMP is in power save mode, it is awakened by the WOM and will wait for a certain duration before going back to sleep. This bitfield configures this duration.</p> <p>0000: 0 seconds  0001: 4 seconds  0010: 8 seconds  0011: 12 seconds  0100: 16 seconds  0101: 20 seconds  0110: 24 seconds  0111: 28 seconds  1000: 32 seconds  1001: 36 seconds  1010: 40 seconds  1011: 44 seconds  1100: 48 seconds  1101: 52 seconds  1110: 56 seconds  1111: 60 seconds</p>

### 17.3 APEX\_CONFIG2

Name: APEX_CONFIG2 Address: 65 (41h) Serial IF: R/W Reset value: 0x85 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	PED_AMP_TH_SEL	Pedometer amplitude threshold selection Use default value 1000b
3:0	PED_STEP_CNT_TH_SEL	Pedometer step count detection window Use default value 0101b 0000: 0 steps 0001: 1 step 0010: 2 steps 0011: 3 steps 0100: 4 steps 0101: 5 steps (default) 0110: 6 steps 0111: 7 steps 1000: 8 steps 1001: 9 steps 1010: 10 steps 1011: 11 steps 1100: 12 steps 1101: 13 steps 1110: 14 steps 1111: 15 steps

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**17.4 APEX\_CONFIG3**

Name: APEX\_CONFIG3

Address: 66 (42h)

Serial IF: R/W

Reset value: 0x51

Clock Domain: SCLK\_UI

BIT	NAME	FUNCTION
7:5	PED_STEP_DET_TH_SEL	Pedometer step detection threshold selection Use default value 010b 000: 0 steps 001: 1 step 010: 2 steps (default) 011: 3 steps 100: 4 steps 101: 5 steps 110: 6 steps 111: 7 steps
4:2	PED_SB_TIMER_TH_SEL	Pedometer step buffer timer threshold selection Use default value 100b 000: 0 samples 001: 1 sample 010: 2 samples 011: 3 samples 100: 4 samples (default) 101: 5 samples 110: 6 samples 111: 7 samples
1:0	PED_HI_EN_TH_SEL	Pedometer high energy threshold selection Use default value 01b

## 17.5 APEX\_CONFIG4

Name: APEX_CONFIG4 Address: 67 (43h) Serial IF: R/W Reset value: 0xA4 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	TILT_WAIT_TIME_SEL	Configures duration of delay after tilt is detected before interrupt is triggered 00: 0s 01: 2s 10: 4s (default) 11: 6s
5:3	SLEEP_TIME_OUT	Configures the time out for sleep detection, for Raise to Wake/Sleep feature 000: 1.28sec 001: 2.56sec 010: 3.84sec 011: 5.12sec 100: 6.40sec 101: 7.68sec 110: 8.96sec 111: 10.24sec
2:0	-	Reserved

## 17.6 APEX\_CONFIG5

Name: APEX_CONFIG5 Address: 68 (44h) Serial IF: R/W Reset value: 0x8C Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:3	-	Reserved
2:0	MOUNTING_MATRIX	Defines mounting matrix, chip to device frame 000: [ 1 0 0; 0 1 0; 0 0 1] 001: [ 1 0 0; 0 -1 0; 0 0 -1] 010: [-1 0 0; 0 1 0; 0 0 -1] 011: [-1 0 0; 0 -1 0; 0 0 1] 100: [ 0 1 0; 1 0 0; 0 0 -1] 101: [ 0 1 0; -1 0 0; 0 0 1] 110: [ 0 -1 0; 1 0 0; 0 0 1] 111: [ 0 -1 0; -1 0 0; 0 0 -1]

### 17.7 APEX\_CONFIG6

Name: APEX_CONFIG6 Address: 69 (45h) Serial IF: R/W Reset value: 0x5C Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:3	-	Reserved
2:0	SLEEP_GESTURE_DELAY	Configures detection window for sleep gesture detection 000: 0.32sec 001: 0.64sec 010: 0.96sec 011: 1.28sec 100: 1.60sec 101: 1.92sec 110: 2.24sec 111: 2.56sec

### 17.8 APEX\_CONFIG7

Name: APEX_CONFIG7 Address: 70 (46h) Serial IF: R/W Reset value: 0x45 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:2	TAP_MIN_JERK_THR	Tap Detection minimum jerk threshold Use default value 010001b
1:0	TAP_MAX_PEAK_TOL	Tap Detection maximum peak tolerance Use default value 01b

### 17.9 APEX\_CONFIG8

Name: APEX_CONFIG8 Address: 71 (47h) Serial IF: R/W Reset value: 0x5B Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7	-	Reserved
6:5	TAP_TMAX	Tap measurement window (number of samples) Use default value 01b
4:3	TAP_TAVG	Tap energy measurement window (number of samples) Use default value 01b
2:0	TAP_TMIN	Single tap window (number of samples) Use default value 011b

### 17.10 ACCEL\_WOM\_X\_THR

Name: ACCEL_WOM_X_THR Address: 74 (4Ah) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	WOM_X_TH	Threshold value for the Wake on Motion Interrupt for X-axis accelerometer WoM thresholds are expressed in fixed "mg" independent of the selected Range [0g : 1g]; Resolution 1g/256≈3.9mg

### 17.11 ACCEL\_WOM\_Y\_THR

Name: ACCEL_WOM_Y_THR Address: 75 (4Bh) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	WOM_Y_TH	Threshold value for the Wake on Motion Interrupt for Y-axis accelerometer WoM thresholds are expressed in fixed "mg" independent of the selected Range [0g : 1g]; Resolution 1g/256≈3.9mg

### 17.12 ACCEL\_WOM\_Z\_THR

Name: ACCEL_WOM_Z_THR Address: 76 (4Ch) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	WOM_Z_TH	Threshold value for the Wake on Motion Interrupt for Z-axis accelerometer WoM thresholds are expressed in fixed "mg" independent of the selected Range [0g : 1g]; Resolution 1g/256≈3.9mg

### 17.13 INT\_SOURCE6

Name: INT_SOURCE6		
Address: 77 (4Dh)		
Serial IF: R/W		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	-	Reserved
5	STEP_DET_INT1_EN	0: Step detect interrupt not routed to INT1 1: Step detect interrupt routed to INT1
4	STEP_CNT_OFL_INT1_EN	0: Step count overflow interrupt not routed to INT1 1: Step count overflow interrupt routed to INT1
3	TILT_DET_INT1_EN	0: Tilt detect interrupt not routed to INT1 1: Tile detect interrupt routed to INT1
2:1	-	Reserved
0	TAP_DET_INT1_EN	0: Tap detect interrupt not routed to INT1 1: Tap detect interrupt routed to INT1

### 17.14 INT\_SOURCE7

Name: INT_SOURCE7		
Address: 78 (4Eh)		
Serial IF: R/W		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:6	-	Reserved
5	STEP_DET_INT2_EN	0: Step detect interrupt not routed to INT2 1: Step detect interrupt routed to INT2
4	STEP_CNT_OFL_INT2_EN	0: Step count overflow interrupt not routed to INT2 1: Step count overflow interrupt routed to INT2
3	TILT_DET_INT2_EN	0: Tilt detect interrupt not routed to INT2 1: Tile detect interrupt routed to INT2
2:1	-	Reserved
0	TAP_DET_INT2_EN	0: Tap detect interrupt not routed to INT2 1: Tap detect interrupt routed to INT2

### 17.15 OFFSET\_USER0

Name: OFFSET_USER0		
Address: 119 (77h)		
Serial IF: R/W		
Reset value: 0x00		
Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_X_OFFUSER[7:0]	Lower bits of X-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.

### 17.16 OFFSET\_USER1

Name: OFFSET_USER1 Address: 120 (78h) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	GYRO_Y_OFFUSER[11:8]	Upper bits of Y-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.
3:0	GYRO_X_OFFUSER[11:8]	Upper bits of X-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.

### 17.17 OFFSET\_USER2

Name: OFFSET_USER2 Address: 121 (79h) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_Y_OFFUSER[7:0]	Lower bits of Y-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.

### 17.18 OFFSET\_USER3

Name: OFFSET_USER3 Address: 122 (7Ah) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	GYRO_Z_OFFUSER[7:0]	Lower bits of Z-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.

### 17.19 OFFSET\_USER4

Name: OFFSET_USER4 Address: 123 (7Bh) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	ACCEL_X_OFFUSER[11:8]	Upper bits of X-accel offset programmed by user. Max value is $\pm 1g$ , resolution is 0.5mg.
3:0	GYRO_Z_OFFUSER[11:8]	Upper bits of Z-gyro offset programmed by user. Max value is $\pm 64$ dps, resolution is 1/32 dps.



## 17.20 OFFSET\_USER5

Name: OFFSET_USER5 Address: 124 (7Ch) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ACCEL_X_OFFUSER[7:0]	Lower bits of X-accel offset programmed by user. Max value is $\pm 1g$ , resolution is 0.5mg.

## 17.21 OFFSET\_USER6

Name: OFFSET_USER6 Address: 125 (7Dh) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ACCEL_Y_OFFUSER[7:0]	Lower bits of Y-accel offset programmed by user. Max value is $\pm 1g$ , resolution is 0.5mg.

## 17.22 OFFSET\_USER7

Name: OFFSET_USER7 Address: 126 (7Eh) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:4	ACCEL_Z_OFFUSER[11:8]	Upper bits of Z-accel offset programmed by user. Max value is $\pm 1g$ , resolution is 0.5mg.
3:0	ACCEL_Y_OFFUSER[11:8]	Upper bits of Y-accel offset programmed by user. Max value is $\pm 1g$ , resolution is 0.5mg.

## 17.23 OFFSET\_USER8

Name: OFFSET_USER8 Address: 127 (7Fh) Serial IF: R/W Reset value: 0x00 Clock Domain: SCLK_UI		
BIT	NAME	FUNCTION
7:0	ACCEL_Z_OFFUSER[7:0]	Lower bits of Z-accel offset programmed by user. Max value is $\pm 1g$ , resolution is 0.5mg.

## **18 REFERENCE**

Please refer to “InvenSense MEMS Handling Application Note (AN-IVS-0002A-00)” for the following information:

- Manufacturing Recommendations
  - Assembly Guidelines and Recommendations
  - PCB Design Guidelines and Recommendations
  - MEMS Handling Instructions
  - ESD Considerations
  - Reflow Specification
  - Storage Specifications
  - Package Marking Specification
  - Tape & Reel Specification
  - Reel & Pizza Box Label
  - Packaging
  - Representative Shipping Carton Label
- Compliance
  - Environmental Compliance
  - DRC Compliance
  - Compliance Declaration Disclaimer

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## 19 DOCUMENT INFORMATION

### 19.1 REVISION HISTORY

Revision Date	Revision	Description
12/04/2017	1.0	Initial Release
03/16/2018	1.1	Updated Section 3
04/25/2018	1.2	Updated Section 11
06/25/2018	1.3	Updated Sections 3, 11, 12, 13, 14, 15
07/23/2018	1.4	Updated Sections 1, 2, 3, 4, 7, 13, 14, 15, 16, 17
10/17/2018	1.5	Updated Section 4
10/18/2018	1.6	Updated Section 3
01/03/2019	1.7	Updated Sections 2, 3, 4, 5, 6, 10, 12, 13, 14, 17

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