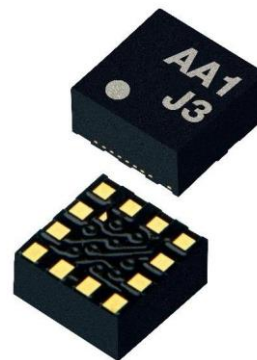


|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|  | <b>± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications</b> | <b>PART NUMBER:</b><br><b>KXTJ3-1057</b><br><b>Rev. 4.0</b><br><b>05-Oct-2018</b> |
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## Product Description

The KXTJ3-1057 is a tri-axis  $\pm 2g$ ,  $\pm 4g$ ,  $\pm 8g$ , or  $\pm 16g$  silicon micromachined accelerometer. The sense element is fabricated using Kionix's proprietary plasma micromachining process technology. Acceleration sensing is based on the principle of a differential capacitance arising from acceleration-induced motion of the sense element, which further utilizes common mode cancellation to decrease errors from process variation, temperature, and environmental stress. The sense element is hermetically sealed at the wafer level by bonding a second silicon lid wafer to the device using a glass frit. A separate ASIC device packaged with the sense element provides signal conditioning and digital communications. The accelerometer is delivered in a 2 x 2 x 0.9 mm LGA plastic package operating from a 1.71V – 3.6V DC supply. Voltage regulators are used to maintain constant internal operating voltages over the range of input supply voltages. This results in stable operating characteristics over the range of input supply voltages and virtually undetectable ratiometric error. The I<sup>2</sup>C digital protocol is used to communicate with the chip to configure the part and monitor outputs.



## Features

- Small footprint: 2 x 2 x 0.9 mm LGA 12-pin package (pin-to-pin compatible with KXTJ2)
- Low current consumption: 0.9  $\mu A$  in standby, 10  $\mu A$  in Low Power, and 155  $\mu A$  in High Resolution modes
- Extended user-configurable g-ranges:  $\pm 2g$ ,  $\pm 4g$ ,  $\pm 8g$ ,  $\pm 16g$
- 8-bit, 12-bit, and 14-bit resolution modes
- Wide supply voltage range: 1.71V – 3.6V with internal voltage regulator
- High resolution Wake-Up function with threshold configurable down to 3.9 mg
- User-configurable Output Data Rates from 0.781Hz to 1600Hz
- I<sup>2</sup>C digital communication interface up to 3.4MHz
- Highly configurable interrupt control
- Embedded Low Pass filter
- Improved design to virtually eliminate post reflow offset and sensitivity shifts
- Improved noise performance
- Stable performance over temperature
- High shock survivability
- Self-test function
- RoHS / REACH compliant

|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|  | <b>± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications</b> | <b>PART NUMBER:</b><br><b>KXTJ3-1057</b><br><b>Rev. 4.0</b><br><b>05-Oct-2018</b> |
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# ± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications

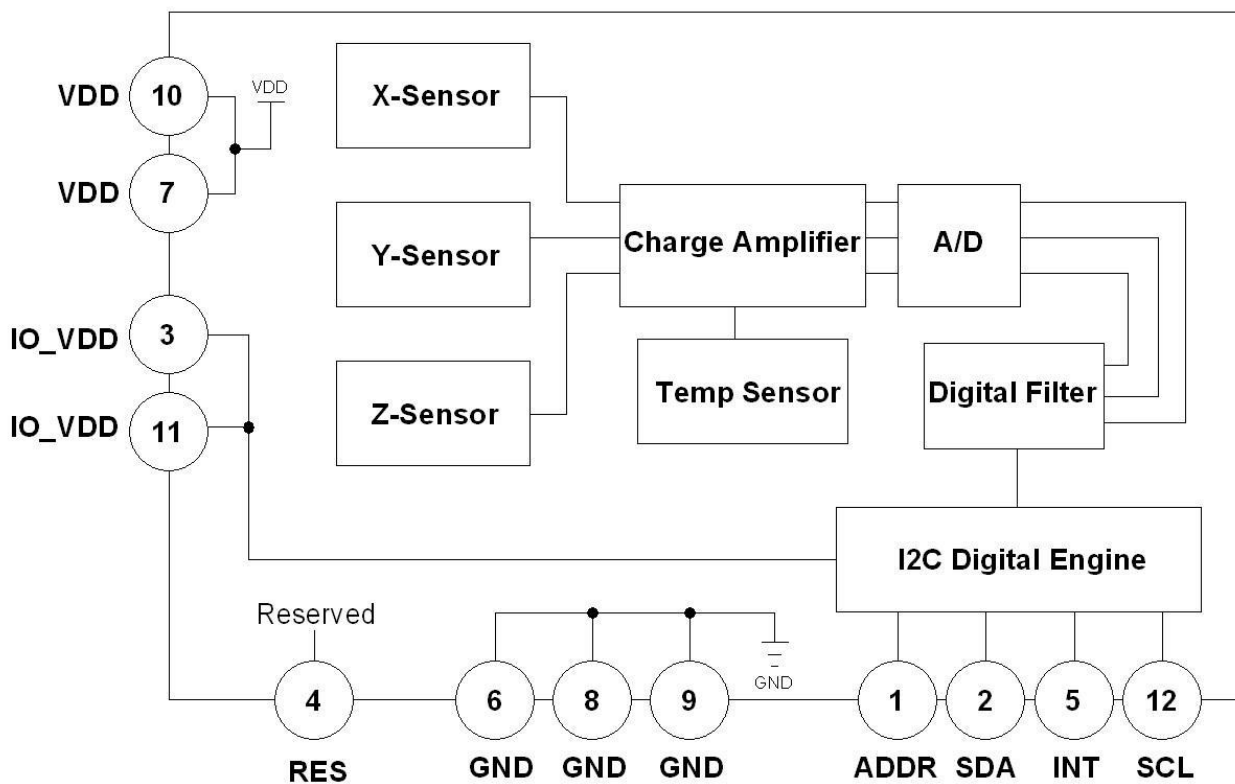
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## Functional Diagram



|                                                                                   |                                                                           |                                                                                   |
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|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|

## Product Specifications

### Mechanical

(specifications are for operation at 2.5V and T = 25C unless stated otherwise)

| Parameters                                                  |               | Units    | Min | Typical | Max |
|-------------------------------------------------------------|---------------|----------|-----|---------|-----|
| Operating Temperature Range                                 |               | °C       | -40 | -       | +85 |
| Zero-g Offset                                               |               | mg       |     | ±25     |     |
| Zero-g Offset Variation from RT over Temp.                  |               | mg/°C    |     | 0.2     |     |
| Sensitivity (14-bit) <sup>1,2</sup>                         | ± 8g          | counts/g |     | 1024    |     |
|                                                             | ± 16g         |          |     | 512     |     |
| Sensitivity (12-bit) <sup>1</sup>                           | ± 2g          | counts/g |     | 1024    |     |
|                                                             | ± 4g          |          |     | 512     |     |
|                                                             | ± 8g          |          |     | 256     |     |
|                                                             | ± 16g         |          |     | 128     |     |
| Sensitivity (8-bit) <sup>1</sup>                            | ± 2g          | counts/g |     | 64      |     |
|                                                             | ± 4g          |          |     | 32      |     |
|                                                             | ± 8g          |          |     | 16      |     |
|                                                             | ± 16g         |          |     | 8       |     |
| Sensitivity Variation from RT over Temp.                    |               | %/°C     |     | 0.01    |     |
| Positive Self-Test Output change on Activation <sup>3</sup> |               | g        |     | 0.5     |     |
| Non-Linearity                                               |               | % of FS  |     | 0.6     |     |
| Cross Axis Sensitivity                                      |               | %        |     | 2       |     |
| Noise <sup>4</sup>                                          | RMS Noise     | mg       |     | 0.7     |     |
|                                                             | Noise Density | µg / √Hz |     | 150     |     |

**Table 1: Mechanical Specifications**

Notes:

- Resolution and acceleration ranges are user selectable via I<sup>2</sup>C and via CTRL\_REG1 register.
- 14-bit Resolution is only available for registers 0x06 – 0x0B in the ±8g or ±16g High Resolution mode
- Self-test can be exercised by setting STPOL bit = 1 in INT\_CTRL\_REG1 register, then writing 0xCA to the SELF\_TEST register.
- Noise is measured in High Resolution mode (RES = 1 in CTRL\_REG1 register) at 50Hz ODR.

|                                                                                   |                                                                           |                                                                                   |
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|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|

## Electrical

(specifications are for operation at 2.5V and T = 25°C unless stated otherwise)

| Parameters                                                       |                                     | Units | Min          | Typical     | Max          |
|------------------------------------------------------------------|-------------------------------------|-------|--------------|-------------|--------------|
| Supply Voltage (VDD)                                             | Operating                           | V     | 1.71         | 2.5         | 3.6          |
| I/O Pads Supply Voltage (IO_VDD)                                 |                                     | V     | 1.7          |             | 3.6          |
| Current Consumption                                              | High Resolution Mode (RES=1)        | μA    |              | 155         |              |
|                                                                  | Low Power Mode <sup>1</sup> (RES=0) |       |              | 10          |              |
|                                                                  | Disabled                            |       |              | 0.9         |              |
| Output Low Voltage (V <sub>OL</sub> ) (IO_VDD < 2V) <sup>2</sup> |                                     | V     | -            | -           | 0.2 * IO_VDD |
| Output Low Voltage (V <sub>OL</sub> ) (IO_VDD ≥ 2V) <sup>2</sup> |                                     | V     | -            | -           | 0.4          |
| Output High Voltage (V <sub>OH</sub> )                           |                                     | V     | 0.8 * IO_VDD | -           | -            |
| Input Low Voltage (V <sub>IL</sub> )                             |                                     | V     | -            | -           | 0.2 * IO_VDD |
| Input High Voltage (V <sub>IH</sub> )                            |                                     | V     | 0.8 * IO_VDD | -           | -            |
| Start Up Time <sup>3</sup>                                       |                                     | ms    |              | ~1/ODR      |              |
| Power Up Time <sup>4</sup>                                       |                                     | ms    |              | 12          | 30           |
| I <sup>2</sup> C Communication Rate                              |                                     | MHz   |              |             | 3.4          |
| I <sup>2</sup> C Slave Address (7-bit) <sup>5</sup>              |                                     |       |              | 0x0E / 0x0F |              |
| Output Data Rate (ODR) <sup>6</sup>                              |                                     | Hz    | 0.781        | 50          | 1600         |
| Output Signal Bandwidth (-3dB) <sup>7</sup>                      | High Resolution Mode (RES=1)        | Hz    |              | ODR/2       |              |
|                                                                  | Low Power Mode (RES=0)              |       |              | 800         |              |

**Table 2: Electrical Specifications**

### Notes:

1. Current varies with Output Data Rate (ODR). See *Current Profile* section for details.
2. For I<sup>2</sup>C communication, this assumes a minimum 1.5kΩ pull-up resistor on SCL and SDA pins.
3. Start up time is from PC1 bit set to 1 in CTRL\_REG1 register to valid outputs. Time varies with Output Data Rate (ODR) and power mode (RES bit setting in CTRL\_REG1 register). See *Figure 1* for details.
4. Power up time is from VDD and IO\_VDD valid to device boot completion.
5. User selectable with ADDR pin. See *Digital Interface* section for details.
6. User selectable through I<sup>2</sup>C. The shown values are typical.
7. User selectable and dependent on ODR setting in DATA\_CTRL\_REG register and RES bit setting in CTRL\_REG1 register.

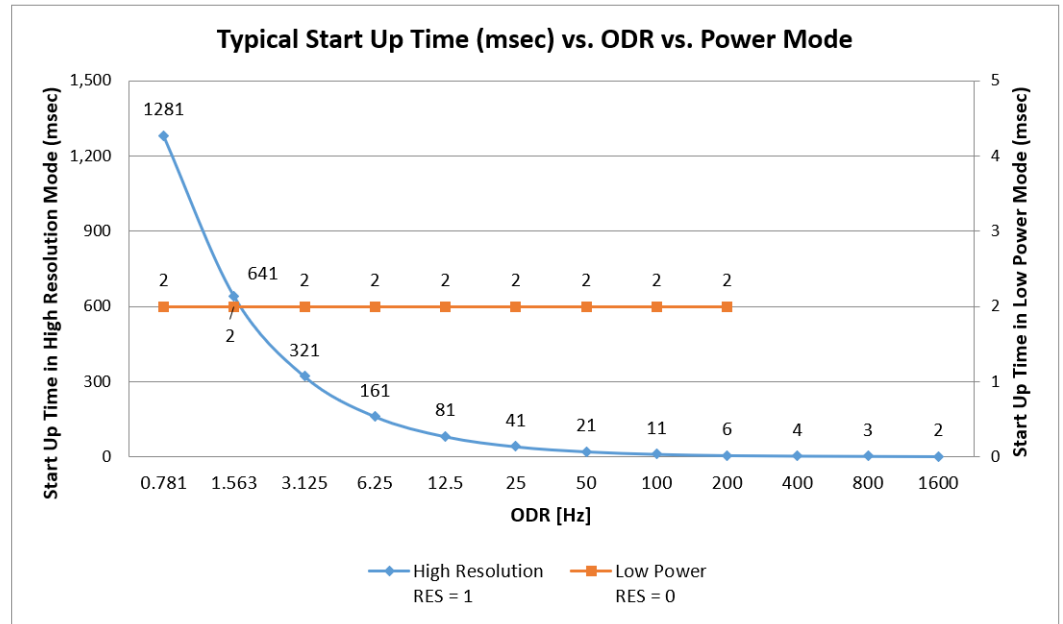


# ± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications

**PART NUMBER:**  
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## Start Up Time Profile

| Typical Start Up Time (msec) |                            |                      |
|------------------------------|----------------------------|----------------------|
| ODR (Hz)                     | High Resolution<br>RES = 1 | Low Power<br>RES = 0 |
| 0.781                        | 1281                       | 2                    |
| 1.563                        | 641                        | 2                    |
| 3.125                        | 321                        | 2                    |
| 6.25                         | 161                        | 2                    |
| 12.5                         | 81                         | 2                    |
| 25                           | 41                         | 2                    |
| 50                           | 21                         | 2                    |
| 100                          | 11                         | 2                    |
| 200                          | 6                          | 2                    |
| 400                          | 4                          | N/A                  |
| 800                          | 3                          | N/A                  |
| 1600                         | 2                          | N/A                  |



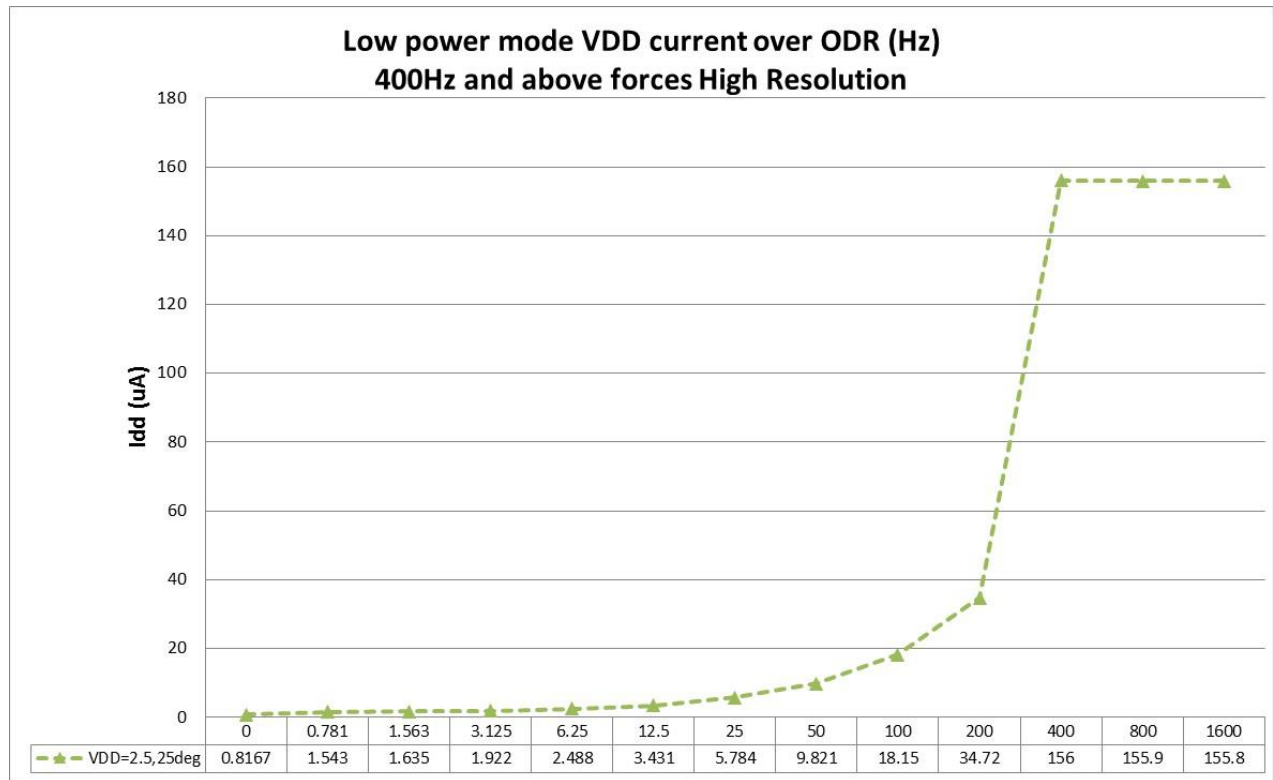
**Figure 1: Typical Start Up Time**



# ± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications

**PART NUMBER:**  
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## Current Profile



**Figure 2: Current Profile**

|                                                                                   |                                                                           |                                                                                   |
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## Power-On Procedure

Proper functioning of power-on reset (POR) is dependent on the specific **VDD**, **VDD<sub>LOW</sub>**, **T<sub>VDD</sub>** (rise time), and **T<sub>VDD\_OFF</sub>** profile of individual applications. It is recommended to minimize **VDD<sub>LOW</sub>**, and **T<sub>VDD</sub>**, and maximize **T<sub>VDD\_OFF</sub>**. It is also advised that the **VDD** ramp up time **T<sub>VDD</sub>** be monotonic. Note that the outputs will not be stable until **VDD** has reached its final value.

- ! *To assure proper POR, the application should be evaluated over the customer specified range of VDD, VDD<sub>LOW</sub>, T<sub>VDD</sub>, T<sub>VDD\_OFF</sub> and temperature as POR performance can vary depending on these parameters.*

Please refer to Technical Note [TN017 Power-On Procedure](#) for more information.

|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
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## Environmental

| Parameters                          |                 | Units | Min  | Typical | Max                               |
|-------------------------------------|-----------------|-------|------|---------|-----------------------------------|
| Supply Voltage (VDD)                | Absolute Limits | V     | -0.5 | -       | 3.63                              |
| Operating Temperature Range         |                 | °C    | -40  | -       | 85                                |
| Storage Temperature Range           |                 | °C    | -55  | -       | 150                               |
| Mech. Shock (powered and unpowered) |                 | g     | -    | -       | 5000 for 0.5ms<br>10000 for 0.2ms |
| ESD                                 | HBM             | V     | -    | -       | 2000                              |

**Table 3:** Environmental Specifications



Caution: ESD Sensitive and Mechanical Shock Sensitive Component, improper handling can cause permanent damage to the device.



This product is in conformance with RoHS directive, REACH regulation, and is Halogen-Free. For the current certificate of compliance, visit [www.kionix.com](http://www.kionix.com) website.

## Handling, Mounting, Soldering

For package handling, mounting, and soldering guidelines, see [TN007 Package Handling, Mounting, and Soldering Guidelines](#) technical note.

## Floor Life

Factory floor life exposure of the KXTJ3 reels removed from the moisture barrier bag should not exceed a maximum of 168 hours at 30C/60%RH. If this floor life is exceeded, the parts should be dried per the IPC/JEDEC J-STD-033D standard (or latest revision).

|                                                                                   |                                                                           |                                                                                   |
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## Terminology

### g

A unit of acceleration equal to the acceleration of gravity at the earth's surface.

$$1g = 9.8 \frac{m}{s^2}$$

One thousandth of a g (0.0098 m/ s<sup>2</sup>) is referred to as 1 milli-g (1 mg).

### Sensitivity

The sensitivity of an accelerometer is the change in output per unit of input acceleration at nominal VDD and temperature. The term is essentially the gain of the sensor expressed in counts per g (counts/g) or LSB's per g (LSB/g). Occasionally, sensitivity is expressed as a resolution, i.e. milli-g per LSB (mg/LSB) or milli-g per count (mg/count). Sensitivity for a given axis is determined by measurements of the formula:

$$Sensitivity = \frac{(Output@+1g - Output@-1g)}{2g}$$

The sensitivity tolerance describes the range of sensitivities that can be expected from a large population of sensors at room temperature and over life. When the temperature deviates from room temperature (25°C), the sensitivity will vary by the amount shown in Table 1.

### Zero-g offset

Zero-g offset or 0-g offset describes the actual output of the accelerometer when no acceleration is applied. Ideally, the output would always be in the middle of the dynamic range of the sensor (content of the XOUT, YOUT, ZOUT registers = 0x00, expressed as a 2's complement number). However, because of mismatches in the sensor, calibration errors, and mechanical stress, the output can deviate from 0x00. This deviation from the ideal value is called 0-g offset. The zero-g offset tolerance describes the range of 0-g offsets of a population of sensors over the operating temperature range.

### Self-test

Self-test allows a functional test of the sensor without applying a physical acceleration to it. When activated, an electrostatic force is applied to the sensor, simulating an input acceleration. The sensor outputs respond accordingly. If the output signals change within the amplitude specified in Table 1, then the sensor is working properly, and the parameters of the interface chip are within the defined specifications.

|                                                                                   |                                                                           |                                                                                   |
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## Functionality

### Sense element

The sense element is fabricated using Kionix's proprietary plasma micromachining process technology. This process technology allows Kionix to create mechanical silicon structures which are essentially mass-spring systems that move in the direction of the applied acceleration. Acceleration sensing is based on the principle of a differential capacitance arising from the acceleration-induced motion. Capacitive plates on the moving mass move relative to fixed capacitive plates anchored to the substrate. The sense element is hermetically sealed at the wafer level by bonding a second silicon lid wafer to the device using a glass frit.

### ASIC interface

A separate ASIC device packaged with the sense element provides all of the signal conditioning and communication with the sensor. The complete measurement chain is composed by a low-noise capacitance to voltage amplifier which converts the differential capacitance of the MEMS sensor into an analog voltage that is sent through an analog-to-digital converter. The acceleration data may be accessed through the I<sup>2</sup>C digital communications provided by the ASIC. In addition, the ASIC contains all of the logic to allow the user to choose data rates, g-ranges, filter settings, and interrupt logic.

### Factory calibration

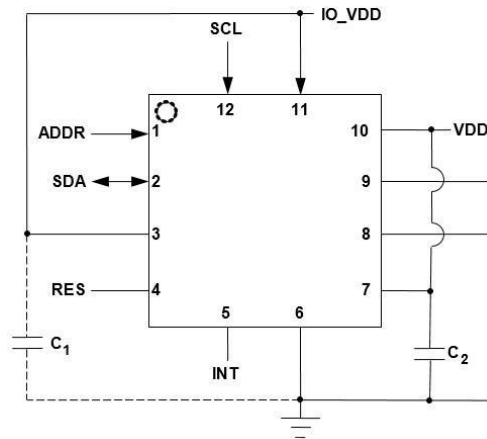
Kionix trims the offset and sensitivity of each accelerometer by adjusting gain (sensitivity) and 0-g offset trim codes stored in non-volatile memory (OTP). Additionally, all functional register default values are also programmed into the nonvolatile memory. Every time the device is turned on or a software reset command is issued, the trimming parameters and default register values are downloaded into the volatile registers to be used during active operation. This allows the device to function without further calibration.



# **± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications**

**PART NUMBER:**  
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## **Application Schematic**



## **Pin Description**

| Pin | Name   | Description                                                                                                                                                  |
|-----|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | ADDR   | I2C Address pin. This pin must be connected to IO_VDD or GND to determine the I2C Device Address.                                                            |
| 2   | SDA    | I2C Serial Data                                                                                                                                              |
| 3   | IO_VDD | The power supply input for the digital communication bus. Optionally decouple this pin to ground with a 0.1uF ceramic capacitor. (Internally tied to Pin 11) |
| 4   | RES    | Reserved. Connect to GND. Optionally, can be connected to IO_VDD or VDD. Do not leave floating.                                                              |
| 5   | INT    | Physical Interrupt pin (Push-Pull). Leave floating if not used.                                                                                              |
| 6   | GND    | Ground. (Internally tied to Pins 8, 9)                                                                                                                       |
| 7   | VDD    | The power supply input. Decouple this pin to ground with a 0.1uF ceramic capacitor. (Internally tied to Pin 10)                                              |
| 8   | GND    | Ground. (Internally tied to Pins 6, 9)                                                                                                                       |
| 9   | GND    | Ground. (Internally tied to Pins 6, 8)                                                                                                                       |
| 10  | VDD    | The power supply input. Decouple this pin to ground with a 0.1uF ceramic capacitor. (Internally tied to Pin 7)                                               |
| 11  | IO_VDD | The power supply input for the digital communication bus. Optionally decouple this pin to ground with a 0.1uF ceramic capacitor. (Internally tied to Pin 3)  |
| 12  | SCL    | I2C Serial Clock                                                                                                                                             |

**Table 4: Pin Description**



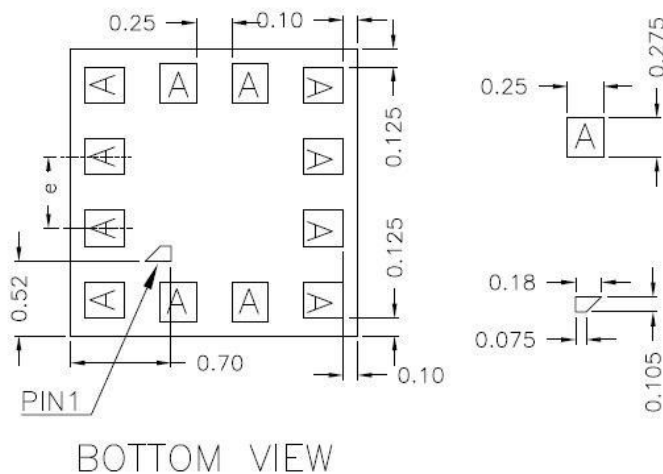
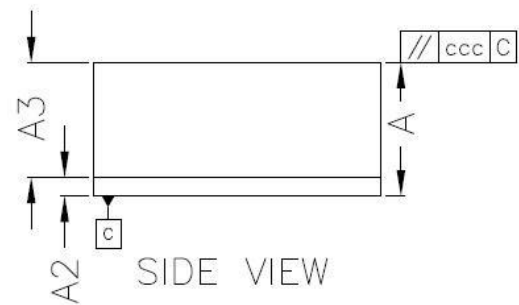
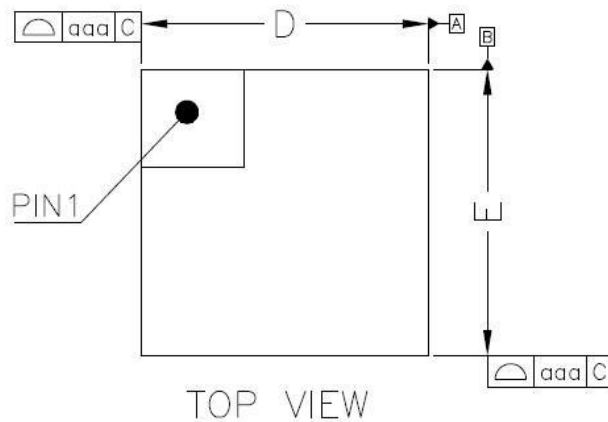
# **± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications**

**PART NUMBER:**  
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## **Package Dimensions and Orientation**

### **Dimensions**

2 x 2 x 0.9 mm LGA



| ALL DIMENSIONS ARE IN MILLIMETERS. |            |      |      |
|------------------------------------|------------|------|------|
| SYMBOL                             | MILLIMETER |      |      |
|                                    | MIN        | NOR  | MAX  |
| A                                  | 0.86       | 0.93 | 1.00 |
| A2                                 | 0.10       | 0.13 | 0.16 |
| A3                                 | 0.76       | 0.80 | 0.84 |
| D                                  | 1.95       | 2.00 | 2.05 |
| E                                  | 1.95       | 2.00 | 2.05 |
| e                                  | 0.50 BSC   |      |      |
| aaa                                | 0.10       |      |      |
| ccc                                | 0.05       |      |      |

PO-WJA220012-S5\_00

All dimensions and tolerances conform to ASME Y14.5M-1994



# **± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications**

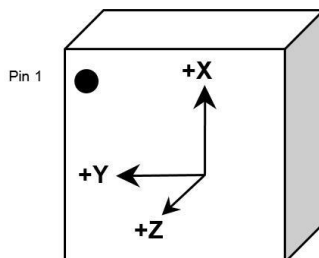
**PART NUMBER:**

**KXTJ3-1057**

**Rev. 4.0**

**05-Oct-2018**

## **Orientation**



When device is accelerated in +X, +Y or +Z direction, the corresponding output will increase.

## **Static X/Y/Z Output Response versus Orientation to Earth's surface (1g):**

GSEL1=0, GSEL0=0, EN16G=0 (±2g)

| Position          | 1     |     | 2     |     | 3     |     | 4     |     | 5             |     | 6             |     |
|-------------------|-------|-----|-------|-----|-------|-----|-------|-----|---------------|-----|---------------|-----|
| Diagram           |       |     |       |     |       |     |       |     | Top<br>Bottom |     | Bottom<br>Top |     |
| Resolution (bits) | 12    | 8   | 12    | 8   | 12    | 8   | 12    | 8   | 12            | 8   | 12            | 8   |
| X (counts)        | +1024 | +64 | 0     | 0   | -1024 | -64 | 0     | 0   | 0             | 0   | 0             | 0   |
| Y (counts)        | 0     | 0   | -1024 | -64 | 0     | 0   | +1024 | +64 | 0             | 0   | 0             | 0   |
| Z (counts)        | 0     | 0   | 0     | 0   | 0     | 0   | 0     | 0   | +1024         | +64 | -1024         | -64 |
| X-Polarity        | +     |     | 0     |     | -     |     | 0     |     | 0             |     | 0             |     |
| Y-Polarity        | 0     |     | -     |     | 0     |     | +     |     | 0             |     | 0             |     |
| Z-Polarity        | 0     |     | 0     |     | 0     |     | 0     |     | +             |     | -             |     |

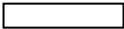
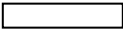


Earth's Surface

|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|  | <b>± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications</b> | <b>PART NUMBER:</b><br><b>KXTJ3-1057</b><br><b>Rev. 4.0</b><br><b>05-Oct-2018</b> |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|

**Static X/Y/Z Output Response versus Orientation to Earth's surface (1g):**

GSEL1=0, GSEL0=1, EN16G=0 (±4g)

| Position          | 1                                                                                 |     | 2                                                                                 |     | 3                                                                                 |     | 4                                                                                 |     | 5                                                                                                    |     | 6                                                                                                    |     |
|-------------------|-----------------------------------------------------------------------------------|-----|-----------------------------------------------------------------------------------|-----|-----------------------------------------------------------------------------------|-----|-----------------------------------------------------------------------------------|-----|------------------------------------------------------------------------------------------------------|-----|------------------------------------------------------------------------------------------------------|-----|
| Diagram           |  |     |  |     |  |     |  |     | Top<br><br>Bottom |     | Bottom<br><br>Top |     |
| Resolution (bits) | 12                                                                                | 8   | 12                                                                                | 8   | 12                                                                                | 8   | 12                                                                                | 8   | 12                                                                                                   | 8   | 12                                                                                                   | 8   |
| X (counts)        | +512                                                                              | +32 | 0                                                                                 | 0   | -512                                                                              | -32 | 0                                                                                 | 0   | 0                                                                                                    | 0   | 0                                                                                                    | 0   |
| Y (counts)        | 0                                                                                 | 0   | -512                                                                              | -32 | 0                                                                                 | 0   | +512                                                                              | +32 | 0                                                                                                    | 0   | 0                                                                                                    | 0   |
| Z (counts)        | 0                                                                                 | 0   | 0                                                                                 | 0   | 0                                                                                 | 0   | 0                                                                                 | 0   | +512                                                                                                 | +32 | -512                                                                                                 | -32 |
| X-Polarity        | +                                                                                 |     | 0                                                                                 |     | -                                                                                 |     | 0                                                                                 |     | 0                                                                                                    |     | 0                                                                                                    |     |
| Y-Polarity        | 0                                                                                 |     | -                                                                                 |     | 0                                                                                 |     | +                                                                                 |     | 0                                                                                                    |     | 0                                                                                                    |     |
| Z-Polarity        | 0                                                                                 |     | 0                                                                                 |     | 0                                                                                 |     | 0                                                                                 |     | +                                                                                                    |     | -                                                                                                    |     |



Earth's Surface

|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|  | <b>± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications</b> | <b>PART NUMBER:</b><br><b>KXTJ3-1057</b><br><b>Rev. 4.0</b><br><b>05-Oct-2018</b> |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|

**Static X/Y/Z Output Response versus Orientation to Earth's surface (1g):**

GSEL1=1, GSEL0=0, EN16G=0 (±8g)  
GSEL1=1, GSEL0=1, EN16G=0 (±8g)<sup>1</sup>

| Position          | 1                                                                                 |      |     | 2                                                                                 |      |     | 3                                                                                 |      |     | 4                                                                                 |      |     | 5                                |      |     | 6                                |      |     |
|-------------------|-----------------------------------------------------------------------------------|------|-----|-----------------------------------------------------------------------------------|------|-----|-----------------------------------------------------------------------------------|------|-----|-----------------------------------------------------------------------------------|------|-----|----------------------------------|------|-----|----------------------------------|------|-----|
| Diagram           |  |      |     |  |      |     |  |      |     |  |      |     | <div>Top</div> <div>Bottom</div> |      |     | <div>Bottom</div> <div>Top</div> |      |     |
| Resolution (bits) | 14                                                                                | 12   | 8   | 14                                                                                | 12   | 8   | 14                                                                                | 12   | 8   | 14                                                                                | 12   | 8   | 14                               | 12   | 8   | 14                               | 12   | 8   |
| X (counts)        | +1024                                                                             | +256 | +16 | 0                                                                                 | 0    | 0   | -1024                                                                             | -256 | -16 | 0                                                                                 | 0    | 0   | 0                                | 0    | 0   | 0                                | 0    | 0   |
| Y (counts)        | 0                                                                                 | 0    | 0   | -1024                                                                             | -256 | -16 | 0                                                                                 | 0    | 0   | +1024                                                                             | +256 | +16 | 0                                | 0    | 0   | 0                                | 0    | 0   |
| Z (counts)        | 0                                                                                 | 0    | 0   | 0                                                                                 | 0    | 0   | 0                                                                                 | 0    | 0   | 0                                                                                 | 0    | 0   | +1024                            | +256 | +16 | -1024                            | -256 | -16 |
| X-Polarity        | +                                                                                 |      |     | 0                                                                                 |      |     | -                                                                                 |      |     | 0                                                                                 |      |     | 0                                |      |     | 0                                |      |     |
| Y-Polarity        | 0                                                                                 |      |     | -                                                                                 |      |     | 0                                                                                 |      |     | +                                                                                 |      |     | 0                                |      |     | 0                                |      |     |
| Z-Polarity        | 0                                                                                 |      |     | 0                                                                                 |      |     | 0                                                                                 |      |     | 0                                                                                 |      |     | +                                |      |     | -                                |      |     |

↓ (1g)

Earth's Surface

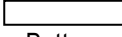
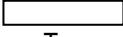
**Notes:**

1. This is applicable for 14-bit mode only in High Resolution mode

|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|  | <b>± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications</b> | <b>PART NUMBER:</b><br><b>KXTJ3-1057</b><br><b>Rev. 4.0</b><br><b>05-Oct-2018</b> |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|

**Static X/Y/Z Output Response versus Orientation to Earth's surface (1g):**

GSEL1=0, GSEL0=0, EN16G=1 (±16g)  
 GSEL1=0, GSEL0=1, EN16G=1 (±16g)  
 GSEL1=1, GSEL0=0, EN16G=1 (±16g)  
 GSEL1=1, GSEL0=1, EN16G=1 (±16g)<sup>1</sup>

| Position          | 1                                                                                 |      |    | 2                                                                                 |      |    | 3                                                                                 |      |    | 4                                                                                  |      |    | 5                                                                                   |      |    | 6                                                                                   |      |    |
|-------------------|-----------------------------------------------------------------------------------|------|----|-----------------------------------------------------------------------------------|------|----|-----------------------------------------------------------------------------------|------|----|------------------------------------------------------------------------------------|------|----|-------------------------------------------------------------------------------------|------|----|-------------------------------------------------------------------------------------|------|----|
| Diagram           |  |      |    |  |      |    |  |      |    |  |      |    |  |      |    |  |      |    |
| Resolution (bits) | 14                                                                                | 12   | 8  | 14                                                                                | 12   | 8  | 14                                                                                | 12   | 8  | 14                                                                                 | 12   | 8  | 14                                                                                  | 12   | 8  | 14                                                                                  | 12   | 8  |
| X (counts)        | +512                                                                              | +128 | +8 | 0                                                                                 | 0    | 0  | -512                                                                              | -128 | -8 | 0                                                                                  | 0    | 0  | 0                                                                                   | 0    | 0  | 0                                                                                   | 0    | 0  |
| Y (counts)        | 0                                                                                 | 0    | 0  | -512                                                                              | -128 | -8 | 0                                                                                 | 0    | 0  | +512                                                                               | +128 | +8 | 0                                                                                   | 0    | 0  | 0                                                                                   | 0    | 0  |
| Z (counts)        | 0                                                                                 | 0    | 0  | 0                                                                                 | 0    | 0  | 0                                                                                 | 0    | 0  | 0                                                                                  | 0    | 0  | +512                                                                                | +128 | +8 | -512                                                                                | -128 | -8 |
| X-Polarity        | +                                                                                 |      |    | 0                                                                                 |      |    | -                                                                                 |      |    | 0                                                                                  |      |    | 0                                                                                   |      |    | 0                                                                                   |      |    |
| Y-Polarity        | 0                                                                                 |      |    | -                                                                                 |      |    | 0                                                                                 |      |    | +                                                                                  |      |    | 0                                                                                   |      |    | 0                                                                                   |      |    |
| Z-Polarity        | 0                                                                                 |      |    | 0                                                                                 |      |    | 0                                                                                 |      |    | 0                                                                                  |      |    | +                                                                                   |      |    | -                                                                                   |      |    |

↓ (1g)

Earth's Surface

Notes:

1. This is applicable for 14-bit mode only in High Resolution mode

|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|  | <b>± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications</b> | <b>PART NUMBER:</b><br><b>KXTJ3-1057</b><br><b>Rev. 4.0</b><br><b>05-Oct-2018</b> |
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## Digital Interface

The Kionix KXTJ3 digital accelerometer has the ability to communicate on the I<sup>2</sup>C digital serial interface bus. This allows for easy system integration by eliminating analog-to-digital converter requirements and by providing direct communication with system micro-controllers.

The serial interface terms and descriptions as indicated in Table 5 will be observed throughout this document.

| Term        | Description                                                                               |
|-------------|-------------------------------------------------------------------------------------------|
| Transmitter | The device that transmits data to the bus.                                                |
| Receiver    | The device that receives data from the bus.                                               |
| Master      | The device that initiates a transfer, generates clock signals, and terminates a transfer. |
| Slave       | The device addressed by the Master.                                                       |

**Table 5:** Serial Interface Terminologies

## I<sup>2</sup>C Serial Interface

As previously mentioned, the KXTJ3 has the ability to communicate on an I<sup>2</sup>C bus. I<sup>2</sup>C is primarily used for synchronous serial communication between a Master device and one or more Slave devices. The Master, typically a micro controller, provides the serial clock signal and addresses Slave devices on the bus. The KXTJ3 always operates as a Slave device during standard Master-Slave I<sup>2</sup>C operation.

I<sup>2</sup>C is a two-wire serial interface that contains a Serial Clock (SCL) line and a Serial Data (SDA) line. SCL is a serial clock that is provided by the Master, but can be held LOW by any Slave device, putting the Master into a wait condition. SDA is a bi-directional line used to transmit and receive data to and from the interface. Data is transmitted MSB (Most Significant Bit) first in 8-bit per byte format, and the number of bytes transmitted per transfer is unlimited. The I<sup>2</sup>C bus is considered free when both lines are HIGH.

The I<sup>2</sup>C interface is compliant with high-speed mode, fast mode and standard mode I<sup>2</sup>C standards.

|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|  | <b>± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications</b> | <b>PART NUMBER:</b><br><b>KXTJ3-1057</b><br><b>Rev. 4.0</b><br><b>05-Oct-2018</b> |
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## I<sup>2</sup>C Operation

Transactions on the I<sup>2</sup>C bus begin after the Master transmits a start condition (S), which is defined as a HIGH-to-LOW transition on the data line while the SCL line is held HIGH. The bus is considered busy after this condition. The next byte of data transmitted after the start condition contains the Slave Address (SAD) in the seven MSBs (Most Significant Bits), and the LSB (Least Significant Bit) tells whether the Master will be receiving data '1' from the Slave or transmitting data '0' to the Slave. When a Slave Address is sent, each device on the bus compares the seven MSBs with its internally stored address. If they match, the device considers itself addressed by the Master. The Slave Address associated with the KXTJ3 is 00011YX, where the user programmable bit X, is determined by the assignment of ADDR pin to GND or IO\_VDD. Also, the factory programmable bit Y is set at the factory. For KXTJ3-1057, the factory programmable bit Y is fixed to 1 (contact your Kionix sales representative for list of available devices). Table 6 lists possible I<sup>2</sup>C addresses for KXTJ3-1057. It is possible to have up to four accelerometers on a shared I<sup>2</sup>C bus as shown in Figure 3 (i.e. two KXTJ3-1057 accelerometers and two additional accelerometers with the factory programmable bit Y set to 0).

|             |             |               |         |     |     |     |     |     | Y   | X   |     |
|-------------|-------------|---------------|---------|-----|-----|-----|-----|-----|-----|-----|-----|
| Description | Address Pad | 7-bit Address | Address | <7> | <6> | <5> | <4> | <3> | <2> | <1> | <0> |
| I2C Wr      | GND         | 0x0E          | 0x1C    | 0   | 0   | 0   | 1   | 1   | 1   | 0   | 0   |
| I2C Rd      | GND         | 0x0E          | 0x1D    | 0   | 0   | 0   | 1   | 1   | 1   | 0   | 1   |
| I2C Wr      | IO_VDD      | 0x0F          | 0x1E    | 0   | 0   | 0   | 1   | 1   | 1   | 1   | 0   |
| I2C Rd      | IO_VDD      | 0x0F          | 0x1F    | 0   | 0   | 0   | 1   | 1   | 1   | 1   | 1   |

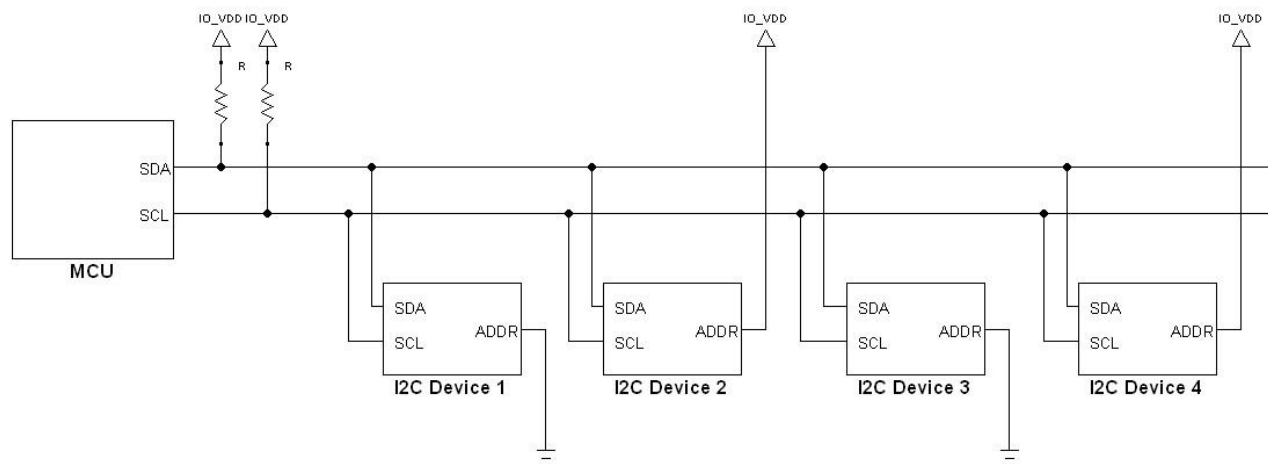
**Table 6:** I<sup>2</sup>C Slave Addresses for KXTJ3-1057

It is mandatory that receiving devices acknowledge (ACK) each transaction. Therefore, the transmitter must release the SDA line during this ACK pulse. The receiver then pulls the data line LOW so that it remains stable LOW during the HIGH period of the ACK clock pulse. A receiver that has been addressed, whether it is Master or Slave, is obliged to generate an ACK after each byte of data has been received. To conclude a transaction, the Master must transmit a stop condition (P) by transitioning the SDA line from LOW to HIGH while SCL is HIGH. The I<sup>2</sup>C bus is now free. Note that if the KXTJ3 is accessed through I<sup>2</sup>C protocol before the startup is finished a NACK signal is sent.



# ± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications

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**Rev. 4.0**  
**05-Oct-2018**



| I <sup>2</sup> C Device | Part Number | ADDR Pin | Slave Address | Bit Y (Bit 1 in 7-bit address) |
|-------------------------|-------------|----------|---------------|--------------------------------|
| 1                       | KXTJ3-1057  | GND      | 0x0E          | Factory Set to 1               |
| 2                       | KXTJ3-1057  | IO_VDD   | 0x0F          | Factory Set to 1               |
| 3                       | *KXMMM      | GND      | 0x0C          | Factory Set to 0               |
| 4                       | *KXMMM      | IO_VDD   | 0x0D          | Factory Set to 0               |

\* KXMMM – contact Kionix sales representative for list of compatible devices

**Figure 3:** Multiple KXTJ3 Accelerometers on a Shared I<sup>2</sup>C Bus

## Writing to an 8-bit Register

Upon power up, the Master must write to the KXTJ3's control registers to set its operational mode. Therefore, when writing to a control register on the I<sup>2</sup>C bus, as shown Sequence 1 below, the following protocol must be observed: After a start condition, SAD+W transmission, and the KXTJ3 ACK has been returned, an 8-bit Register Address (RA) command is transmitted by the Master. This command is telling the KXTJ3 to which 8-bit register the Master will be writing the data. Since this is I<sup>2</sup>C mode, the MSB of the RA command should always be zero (0). The KXTJ3 acknowledges the RA and the Master transmits the data to be stored in the 8-bit register. The KXTJ3 acknowledges that it has received the data and the Master transmits a stop condition (P) to end the data transfer. The data sent to the KXTJ3 is now stored in the appropriate register. The KXTJ3 automatically increments the received RA commands and, therefore, multiple bytes of data can be written to sequential registers after each Slave ACK as shown in Sequence 2 on the following page.

**\*\*Note\*\*** If a STOP condition is sent on the least significant bit of write data or the following master acknowledge cycle, the last write operation is not guaranteed and it may alter the content of the affected registers.

|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|  | <b>± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications</b> | <b>PART NUMBER:</b><br><b>KXTJ3-1057</b><br><b>Rev. 4.0</b><br><b>05-Oct-2018</b> |
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## Reading from an 8-bit Register

When reading data from a KXTJ3 8-bit register on the I<sup>2</sup>C bus, as shown in Sequence 3 on the next page, the following protocol must be observed: The Master first transmits a start condition (S) and the appropriate Slave Address (SAD) with the LSB set at '0' to write. The KXTJ3 acknowledges and the Master transmits the 8-bit RA of the register it wants to read. The KXTJ3 again acknowledges, and the Master transmits a repeated start condition (Sr). After the repeated start condition, the Master addresses the KXTJ3 with a '1' in the LSB (SAD+R) to read from the previously selected register. The Slave then acknowledges and transmits the data from the requested register. The Master does not acknowledge (NACK) it received the transmitted data but transmits a stop condition to end the data transfer. Note that the KXTJ3 automatically increments through its sequential registers, allowing data to be read from multiple registers following a single SAD+R command as shown below in Sequence 4. The 8-bit register data is transmitted using a left-most format, first bit shifted/clocked out being the MSB bit. If a receiver cannot transmit or receive another complete byte of data until it has performed some other function, it can hold SCL LOW to force the transmitter into a wait state. Data transfer only continues when the receiver is ready for another byte and releases SCL.

**\*\*Note\*\*** Accelerometer's output data should be read in a single transaction using the auto-increment feature to prevent output data from being updated prior to intended completion of the read transaction.

|                                                                                   |                                                                           |                                                                                   |
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## Data Transfer Sequences

The following information clearly illustrates the variety of data transfers that can occur on the I<sup>2</sup>C bus and how the Master and Slave interact during these transfers. Table 7 defines the I<sup>2</sup>C terms used during the data transfers.

| Term | Definition                |
|------|---------------------------|
| S    | Start Condition           |
| Sr   | Repeated Start Condition  |
| SAD  | Slave Address             |
| W    | Write Bit                 |
| R    | Read Bit                  |
| ACK  | Acknowledge               |
| NACK | Not Acknowledge           |
| RA   | Register Address          |
| Data | Transmitted/Received Data |
| P    | Stop Condition            |

**Table 7:** I<sup>2</sup>C Terms

**Sequence 1:** The Master is writing one byte to the Slave.

|        |   |         |     |    |     |      |     |   |
|--------|---|---------|-----|----|-----|------|-----|---|
| Master | S | SAD + W |     | RA |     | DATA |     | P |
| Slave  |   |         | ACK |    | ACK |      | ACK |   |

**Sequence 2:** The Master is writing multiple bytes to the Slave.

|        |   |         |     |    |     |      |     |      |     |   |
|--------|---|---------|-----|----|-----|------|-----|------|-----|---|
| Master | S | SAD + W |     | RA |     | DATA |     | DATA |     | P |
| Slave  |   |         | ACK |    | ACK |      | ACK |      | ACK |   |

**Sequence 3:** The Master is receiving one byte of data from the Slave.

|        |   |         |     |    |     |    |         |     |      |      |   |
|--------|---|---------|-----|----|-----|----|---------|-----|------|------|---|
| Master | S | SAD + W |     | RA |     | Sr | SAD + R |     |      | NACK | P |
| Slave  |   |         | ACK |    | ACK |    |         | ACK | DATA |      |   |

**Sequence 4:** The Master is receiving multiple bytes of data from the Slave.

|        |   |         |     |    |     |    |         |     |      |     |      |      |   |
|--------|---|---------|-----|----|-----|----|---------|-----|------|-----|------|------|---|
| Master | S | SAD + W |     | RA |     | Sr | SAD + R |     |      | ACK |      | NACK | P |
| Slave  |   |         | ACK |    | ACK |    |         | ACK | DATA |     | DATA |      |   |

|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
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## HS-mode

To enter the 3.4MHz high speed mode of communication, the device must receive the following sequence of conditions from the master: a Start condition followed by a Master code (00001XXX) and a Master Non-acknowledge. Once recognized, the device switches to HS-mode communication. Read/write data transfers then proceed as described in the sequences above. Devices return to the FS-mode after a STOP occurrence on the bus.

**Sequence 5:** HS-mode data transfer of the Master writing multiple bytes to the Slave.

| Speed  | FS-mode |        |      | HS-mode |         |     |    |     |      |     |   | FS-mode |
|--------|---------|--------|------|---------|---------|-----|----|-----|------|-----|---|---------|
| Master | S       | M-code | NACK | Sr      | SAD + W |     | RA |     | DATA |     | P |         |
| Slave  |         |        |      |         |         | ACK |    | ACK |      | ACK |   |         |

n bytes + ack.

**Sequence 6:** HS-mode data transfer of the Master receiving multiple bytes of data from the Slave.

| Speed  | FS-mode |        |      | HS-mode |         |     |    |     |
|--------|---------|--------|------|---------|---------|-----|----|-----|
| Master | S       | M-code | NACK | Sr      | SAD + W |     | RA |     |
| Slave  |         |        |      |         |         | ACK |    | ACK |

| Speed  | HS-mode |         |     |      |     |      |      |   | FS-mode |
|--------|---------|---------|-----|------|-----|------|------|---|---------|
| Master | Sr      | SAD + R |     |      |     |      | NACK | P |         |
| Slave  |         |         | ACK | DATA | ACK | DATA |      |   |         |

(n-1) bytes +  
ack.



# **± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications**

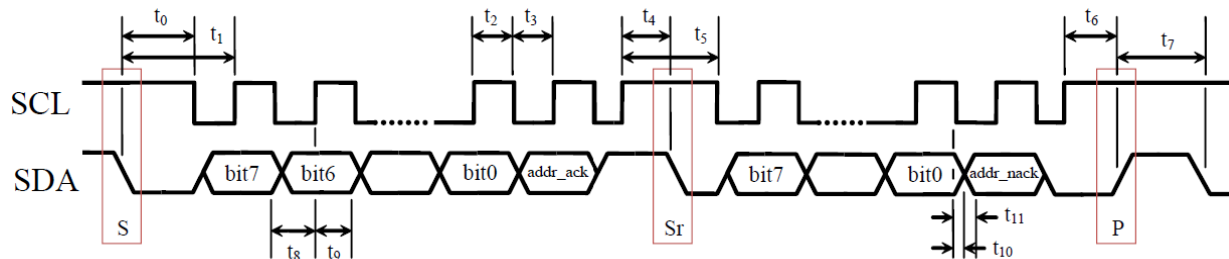
**PART NUMBER:**

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**Rev. 4.0**

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## **I<sup>2</sup>C Timing Diagram**



| Number          | Description                                       | MIN | MAX | Units |
|-----------------|---------------------------------------------------|-----|-----|-------|
| t <sub>0</sub>  | SDA LOW to SCL LOW transition (Start event)       | 50  | -   | ns    |
| t <sub>1</sub>  | SDA LOW to first SCL rising edge                  | 100 | -   | ns    |
| t <sub>2</sub>  | SCL pulse width: HIGH                             | 100 | -   | ns    |
| t <sub>3</sub>  | SCL pulse width: LOW                              | 100 | -   | ns    |
| t <sub>4</sub>  | SCL HIGH before SDA falling edge (Start Repeated) | 50  | -   | ns    |
| t <sub>5</sub>  | SCL pulse width: HIGH during a S/Sr/P event       | 100 | -   | ns    |
| t <sub>6</sub>  | SCL HIGH before SDA rising edge (Stop)            | 50  | -   | ns    |
| t <sub>7</sub>  | SDA pulse width: HIGH                             | 25  | -   | ns    |
| t <sub>8</sub>  | SDA valid to SCL rising edge                      | 50  | -   | ns    |
| t <sub>9</sub>  | SCL rising edge to SDA invalid                    | 50  | -   | ns    |
| t <sub>10</sub> | SCL falling edge to SDA valid (when slave is      | -   | 100 | ns    |
| t <sub>11</sub> | SCL falling edge to SDA invalid (when slave is    | 0   | -   | ns    |
| Note            | Recommended I <sup>2</sup> C CLK                  | 2.5 | -   | μs    |

**Table 8: I<sup>2</sup>C Timing (Fast Mode)**

|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
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## Embedded Registers

The KXTJ3 has 20 embedded 8-bit registers that are accessible by the user. This section contains the addresses for all embedded registers and describes bit functions of each register.

| Register Name       | Type (R/W) | Register Address (Hex) |
|---------------------|------------|------------------------|
| Kionix Reserved     | -          | 0x00 – 0x05            |
| XOUT_L              | R          | 0x06                   |
| XOUT_H              | R          | 0x07                   |
| YOUT_L              | R          | 0x08                   |
| YOUT_H              | R          | 0x09                   |
| ZOUT_L              | R          | 0x0A                   |
| ZOUT_H              | R          | 0x0B                   |
| DCST_RESP           | R          | 0x0C                   |
| Kionix Reserved     | -          | 0x0D – 0x0E            |
| WHO_AM_I            | R          | 0x0F                   |
| Kionix Reserved     | -          | 0x10 – 0 x15           |
| INT_SOURCE1         | R          | 0x16                   |
| INT_SOURCE2         | R          | 0x17                   |
| STATUS_REG          | R          | 0x18                   |
| Kionix Reserved     | -          | 0x19                   |
| INT_REL             | R          | 0x1A                   |
| CTRL_REG1*          | R/W        | 0x1B                   |
| Kionix Reserved     | -          | 0x1C                   |
| CTRL_REG2*          | R/W        | 0x1D                   |
| INT_CTRL_REG1*      | R/W        | 0x1E                   |
| INT_CTRL_REG2*      | R/W        | 0x1F                   |
| Kionix Reserved     | -          | 0x20                   |
| DATA_CTRL_REG*      | R/W        | 0x21                   |
| Kionix Reserved     | -          | 0x22 – 0x28            |
| WAKEUP_COUNTER*     | R/W        | 0x29                   |
| NA_COUNTER*         | R/W        | 0x2A                   |
| Kionix Reserved     | -          | 0x2B – 0x39            |
| SELF_TEST*          | W          | 0x3A                   |
| Kionix Reserved     | -          | 0x3B – 0x69            |
| WAKEUP_THRESHOLD_H* | R/W        | 0x6A                   |
| WAKEUP_THRESHOLD_L* | R/W        | 0x6B                   |

**Table 9: Register Map**

\* Note: When changing the contents of these registers, the PC1 bit in CTRL\_REG1 must first be set to “0”

|                                                                                   |                                                                           |                                                                                   |
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## Register Descriptions

### Accelerometer Outputs

These registers contain up to 14-bits of valid acceleration data for each. The data is updated every user-defined ODR period, is protected from overwrite during each read, and can be converted from digital counts to acceleration (g) per Table 10 below. The register acceleration output binary data is represented in 2's complement format. For example, if N = 14 bits, then the Counts range is from -8192 to 8191, if N = 12 bits, then the Counts range is from -2048 to 2047, and if N = 8 bits, then the Counts range is from -128 to 127.

| 14-bit Register Data (2's complement) | Equivalent Counts in decimal | Range = ±2g   | Range = ±4g   | Range = ±8g | Range = ±16g |
|---------------------------------------|------------------------------|---------------|---------------|-------------|--------------|
| 00011111111111                        | 8191                         | Not available | Not available | +7.999g     | +15.998g     |
| 00011111111110                        | 8190                         | Not available | Not available | +7.998g     | +15.996g     |
| ...                                   | ...                          | ...           | ...           | ...         | ...          |
| 00000000000001                        | 1                            | Not available | Not available | +0.00098g   | +0.00195g    |
| 00000000000000                        | 0                            | Not available | Not available | 0.000g      | 0.000g       |
| 11111111111111                        | -1                           | Not available | Not available | -0.00098g   | -0.00195g    |
| ...                                   | ...                          | ...           | ...           | ...         | ...          |
| 11100000000001                        | -8191                        | Not available | Not available | -7.999g     | -15.998g     |
| 11100000000000                        | -8192                        | Not available | Not available | -8.000g     | -16.000g     |

| 12-bit Register Data (2's complement) | Equivalent Counts in decimal | Range = ±2g | Range = ±4g | Range = ±8g | Range = ±16g |
|---------------------------------------|------------------------------|-------------|-------------|-------------|--------------|
| 0111 1111 1111                        | 2047                         | +1.999g     | +3.998g     | +7.996g     | +15.992g     |
| 0111 1111 1110                        | 2046                         | +1.998g     | +3.996g     | +7.992g     | +15.984g     |
| ...                                   | ...                          | ...         | ...         | ...         | ...          |
| 0000 0000 0001                        | 1                            | +0.001g     | +0.002g     | +0.0039g    | +0.0078g     |
| 0000 0000 0000                        | 0                            | 0.000g      | 0.000g      | 0.0000g     | 0.0000g      |
| 1111 1111 1111                        | -1                           | -0.001g     | -0.002g     | -0.0039g    | -0.0078g     |
| ...                                   | ...                          | ...         | ...         | ...         | ...          |
| 1000 0000 0001                        | -2047                        | -1.999g     | -3.998g     | -7.996g     | -15.992g     |
| 1000 0000 0000                        | -2048                        | -2.000g     | -4.000g     | -8.000g     | -16.000g     |



# **± 2g / 4g / 8g / 16g Tri-axis Digital Accelerometer Specifications**

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| 8-bit Register Data (2's complement) | Equivalent Counts in decimal | Range = ±2g | Range = ±4g | Range = ±8g | Range = ±16g |
|--------------------------------------|------------------------------|-------------|-------------|-------------|--------------|
| 0111 1111                            | 127                          | +1.984g     | +3.969g     | +7.938g     | +15.875g     |
| 0111 1110                            | 126                          | +1.969g     | +3.938g     | +7.875g     | +15.75g      |
| ...                                  | ...                          | ...         | ...         | ...         | ...          |
| 0000 0001                            | 1                            | +0.016g     | +0.031g     | +0.0625g    | +0.125g      |
| 0000 0000                            | 0                            | 0.000g      | 0.000g      | 0.000g      | 0.000g       |
| 1111 1111                            | -1                           | -0.016g     | -0.031g     | -0.0625g    | -0.125g      |
| ...                                  | ...                          | ...         | ...         | ...         | ...          |
| 1000 0001                            | -127                         | -1.984g     | -3.969g     | -7.938g     | -15.875g     |
| 1000 0000                            | -128                         | -2.000g     | -4.000g     | -8.000g     | -16.000g     |

**Table 10: Acceleration (g) Calculation**

|                                                                                   |                                                                           |                                                                                   |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
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## XOUT\_L

X-axis accelerometer output least significant byte

| R             | R      | R      | R      | R      | R      | R    | R    | Resolution |
|---------------|--------|--------|--------|--------|--------|------|------|------------|
| XOUTD5        | XOUTD4 | XOUTD3 | XOUTD2 | XOUTD1 | XOUTD0 | X    | X    | 14-bit     |
| XOUTD3        | XOUTD2 | XOUTD1 | XOUTD0 | X      | X      | X    | X    | 12-bit     |
| X             | X      | X      | X      | X      | X      | X    | X    | 8-bit      |
| Bit7          | Bit6   | Bit5   | Bit4   | Bit3   | Bit2   | Bit1 | Bit0 |            |
| Address: 0x06 |        |        |        |        |        |      |      |            |

## XOUT\_H

X-axis accelerometer output most significant byte

| R             | R       | R       | R       | R      | R      | R      | R      | Resolution |
|---------------|---------|---------|---------|--------|--------|--------|--------|------------|
| XOUTD13       | XOUTD12 | XOUTD11 | XOUTD10 | XOUTD9 | XOUTD8 | XOUTD7 | XOUTD6 | 14-bit     |
| XOUTD11       | XOUTD10 | XOUTD9  | XOUTD8  | XOUTD7 | XOUTD6 | XOUTD5 | XOUTD4 | 12-bit     |
| XOUTD7        | XOUTD6  | XOUTD5  | XOUTD4  | XOUTD3 | XOUTD2 | XOUTD1 | XOUTD0 | 8-bit      |
| Bit7          | Bit6    | Bit5    | Bit4    | Bit3   | Bit2   | Bit1   | Bit0   |            |
| Address: 0x07 |         |         |         |        |        |        |        |            |

## YOUT\_L

Y-axis accelerometer output least significant byte

| R             | R      | R      | R      | R      | R      | R    | R    | Resolution |
|---------------|--------|--------|--------|--------|--------|------|------|------------|
| YOUTD5        | YOUTD4 | YOUTD3 | YOUTD2 | YOUTD1 | YOUTD0 | Y    | Y    | 14-bit     |
| YOUTD3        | YOUTD2 | YOUTD1 | YOUTD0 | X      | X      | X    | X    | 12-bit     |
| X             | X      | X      | X      | X      | X      | X    | X    | 8-bit      |
| Bit7          | Bit6   | Bit5   | Bit4   | Bit3   | Bit2   | Bit1 | Bit0 |            |
| Address: 0x08 |        |        |        |        |        |      |      |            |

## YOUT\_H

Y-axis accelerometer output most significant byte

| R             | R       | R       | R       | R      | R      | R      | R      | Resolution |
|---------------|---------|---------|---------|--------|--------|--------|--------|------------|
| YOUTD13       | YOUTD12 | YOUTD11 | YOUTD10 | YOUTD9 | YOUTD8 | YOUTD7 | YOUTD6 | 14-bit     |
| YOUTD11       | YOUTD10 | YOUTD9  | YOUTD8  | YOUTD7 | YOUTD6 | YOUTD5 | YOUTD4 | 12-bit     |
| YOUTD7        | YOUTD6  | YOUTD5  | YOUTD4  | YOUTD3 | YOUTD2 | YOUTD1 | YOUTD0 | 8-bit      |
| Bit7          | Bit6    | Bit5    | Bit4    | Bit3   | Bit2   | Bit1   | Bit0   |            |
| Address: 0x09 |         |         |         |        |        |        |        |            |

|                                                                                   |                                                                           |                                                                                   |
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## ZOUT\_L

Z-axis accelerometer output least significant byte

| R             | R      | R      | R      | R      | R      | R    | R    | Resolution |
|---------------|--------|--------|--------|--------|--------|------|------|------------|
| ZOUTD5        | ZOUTD4 | ZOUTD3 | ZOUTD2 | ZOUTD1 | ZOUTD0 | Y    | Y    | 14-bit     |
| ZOUTD3        | ZOUTD2 | ZOUTD1 | ZOUTD0 | X      | X      | X    | X    | 12-bit     |
| X             | X      | X      | X      | X      | X      | X    | X    | 8-bit      |
| Bit7          | Bit6   | Bit5   | Bit4   | Bit3   | Bit2   | Bit1 | Bit0 |            |
| Address: 0x0A |        |        |        |        |        |      |      |            |

## ZOUT\_H

Z-axis accelerometer output most significant byte

| R             | R       | R       | R       | R      | R      | R      | R      | Resolution |
|---------------|---------|---------|---------|--------|--------|--------|--------|------------|
| ZOUTD13       | ZOUTD12 | ZOUTD11 | ZOUTD10 | ZOUTD9 | ZOUTD8 | ZOUTD7 | ZOUTD6 | 14-bit     |
| ZOUTD11       | ZOUTD10 | ZOUTD9  | ZOUTD8  | ZOUTD7 | ZOUTD6 | ZOUTD5 | ZOUTD4 | 12-bit     |
| ZOUTD7        | ZOUTD6  | ZOUTD5  | ZOUTD4  | ZOUTD3 | ZOUTD2 | ZOUTD1 | ZOUTD0 | 8-bit      |
| Bit7          | Bit6    | Bit5    | Bit4    | Bit3   | Bit2   | Bit1   | Bit0   |            |
| Address: 0x0B |         |         |         |        |        |        |        |            |

## DCST\_RESP

This register can be used to verify proper integrated circuit functionality. It always has a byte value of 0x55 unless the DCST bit in CTRL\_REG2 is set. At that point this value is set to 0xAA. The byte value is returned to 0x55 after reading this register.

| R             | R      | R      | R      | R      | R      | R      | R      | Reset Value |
|---------------|--------|--------|--------|--------|--------|--------|--------|-------------|
| DCSTR7        | DCSTR6 | DCSTR5 | DCSTR4 | DCSTR3 | DCSTR2 | DCSTR1 | DCSTR0 | 01010101    |
| Bit7          | Bit6   | Bit5   | Bit4   | Bit3   | Bit2   | Bit1   | Bit0   |             |
| Address: 0x0C |        |        |        |        |        |        |        |             |

## WHO\_AM\_I

This register can be used for supplier recognition, as it can be factory written to a known byte value. The default value is 0x35.

| R             | R    | R    | R    | R    | R    | R    | R    | Reset Value |
|---------------|------|------|------|------|------|------|------|-------------|
| WIA7          | WIA6 | WIA5 | WIA4 | WIA3 | WIA2 | WIA1 | WIA0 | 00110101    |
| Bit7          | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |             |
| Address: 0x0F |      |      |      |      |      |      |      |             |

|                                                                                   |                                                                           |                                                                                   |
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## Interrupt Source Registers

These two registers report interrupt state changes. This data is updated when a new interrupt event occurs and each application's result is latched until the interrupt release register is read. The programmable interrupt engine can be configured to report data in an unlatched manner via the interrupt control registers.

### INT\_SOURCE1

This register reports which function caused an interrupt. Reading from the interrupt release register (*INT\_REL*) will clear the entire contents of this register.

|               |      |      |      |      |      |      |      |
|---------------|------|------|------|------|------|------|------|
| R             | R    | R    | R    | R    | R    | R    | R    |
| 0             | 0    | 0    | DRDY | 0    | 0    | WUFS | 0    |
| Bit7          | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
| Address: 0x16 |      |      |      |      |      |      |      |

**DRDY** – indicates that new acceleration data (0x06 to 0x0B) is available. This bit is cleared when acceleration data is read or the interrupt release register (*INT\_REL*) is read.

0 = New acceleration data not available  
1 = New acceleration data available

**WUFS** – Wake-up has occurred. This bit is cleared when the interrupt source latch register (*INT\_REL*) is read (see Table 15 for details).

0 = No motion  
1 = Motion has activated the interrupt

### INT\_SOURCE2

This register reports the axis and direction of detected motion per Table 11. This register is cleared when the interrupt source latch register (*INT\_REL*) is read (see Table 15 for details).

|               |      |      |      |      |      |      |      |
|---------------|------|------|------|------|------|------|------|
| R             | R    | R    | R    | R    | R    | R    | R    |
| 0             | 0    | XNWU | XPWU | YNWU | YPWU | ZNWU | ZPWU |
| Bit7          | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
| Address: 0x17 |      |      |      |      |      |      |      |



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| Bit  | Description              |
|------|--------------------------|
| XNWU | X Negative (X-) Reported |
| XPWU | X Positive (X+) Reported |
| YNWU | Y Negative (Y-) Reported |
| YPWU | Y Positive (Y+) Reported |
| ZNWU | Z Negative (Z-) Reported |
| ZPWU | Z Positive (Z+) Reported |

**Table 11: Motion Reporting**

## **STATUS\_REG**

This register reports the status of the interrupt.

|               |      |      |      |      |      |      |      |
|---------------|------|------|------|------|------|------|------|
| R             | R    | R    | R    | R    | R    | R    | R    |
| 0             | 0    | 0    | INT  | 0    | 0    | 0    | 0    |
| Bit7          | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
| Address: 0x18 |      |      |      |      |      |      |      |

**INT** – reports the combined (OR) interrupt information of *DRDY* and *WUFS* in the interrupt source register (*INT\_SOURCE1*). This bit is cleared when acceleration data is read or the interrupt release register (*INT\_REL*) is read (see Table 15 for details).  
0 = no interrupt event  
1 = interrupt event has occurred

## **INT\_REL**

Latched interrupt source information (*INT\_SOURCE1* and *INT\_SOURCE2*) is cleared and physical interrupt latched pin (INT) is changed to its inactive state when this register is read (see Table 15 for details).

|               |      |      |      |      |      |      |      |
|---------------|------|------|------|------|------|------|------|
| R             | R    | R    | R    | R    | R    | R    | R    |
| X             | X    | X    | X    | X    | X    | X    | X    |
| Bit7          | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
| Address: 0x1A |      |      |      |      |      |      |      |

|                                                                                   |                                                                           |                                                                                   |
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## CTRL\_REG1

Read/write control register that controls the main feature set.

| R/W           | R/W  | R/W   | R/W   | R/W   | R/W   | R/W  | R/W  |             |
|---------------|------|-------|-------|-------|-------|------|------|-------------|
| PC1           | RES  | DRDYE | GSEL1 | GSEL0 | EN16G | WUFE | 0    | Reset Value |
| Bit7          | Bit6 | Bit5  | Bit4  | Bit3  | Bit2  | Bit1 | Bit0 | 00000000    |
| Address: 0x1B |      |       |       |       |       |      |      |             |

**PC1** – controls the operating mode of the KXTJ3.

0 = stand-by mode

1 = operating mode

**RES** – determines the performance mode of the KXTJ3. Note that to change the value of this bit, the PC1 bit must first be set to “0”.

0 = Low Power, 8-bit valid. Only available for ODR ≤ 200 Hz. Bandwidth (Hz) = 800.

1 = High Resolution, 12-bit or 14-bit valid. Bandwidth (Hz) = ODR/2

**DRDYE** – enables the reporting of the availability of new acceleration data as an interrupt. Note that to change the value of this bit, the PC1 bit must first be set to “0”.

0 = availability of new acceleration data is not reflected as an interrupt

1 = availability of new acceleration data is reflected as an interrupt

**GSEL1, GSEL0, EN16G** – selects the acceleration range of the accelerometer outputs per Table 12. Note that to change the value of this bit, the PC1 bit must first be set to “0”.

| GSEL1 | GSEL0 | EN16G | Range             |
|-------|-------|-------|-------------------|
| 0     | 0     | 0     | ±2g               |
| 0     | 1     | 0     | ±4g               |
| 1     | 0     | 0     | ±8g               |
| 1     | 1     | 0     | ±8g <sup>1</sup>  |
| 0     | 0     | 1     | ±16g              |
| 0     | 1     | 1     | ±16g              |
| 1     | 0     | 1     | ±16g              |
| 1     | 1     | 1     | ±16g <sup>1</sup> |

**Table 12:** Selected Acceleration Range

**WUFE** – enables the Wake-Up (motion detect) function. Note that to change the value of this bit, the PC1 bit must first be set to “0”.

0 = Wake-Up function disabled

1 = Wake-Up function enabled

<sup>1</sup> This is a 14-bit mode available only in High Resolution mode and only for Registers 0x06h-0x0Bh

|                                                                                   |                                                                           |                                                                                   |
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## CTRL\_REG2

Read/write control register that provides more feature set control. Note that to properly change the value of this register, the PC1 bit in CTRL\_REG1 must first be set to “0”.

| R/W           | R/W      | R/W      | R/W  | R/W      | R/W   | R/W   | R/W   |             |
|---------------|----------|----------|------|----------|-------|-------|-------|-------------|
| SRST          | Reserved | Reserved | DCST | Reserved | OWUFA | OWUFB | OWUFC | Reset Value |
| Bit7          | Bit6     | Bit5     | Bit4 | Bit3     | Bit2  | Bit1  | Bit0  | 00000000    |
| Address: 0x1D |          |          |      |          |       |       |       |             |

**SRST** – initiates software reset, which performs the RAM reboot routine. This bit will remain 1 until the RAM reboot routine is finished. Please refer to Technical Note [TN017 Power-On Procedure](#) for more information on software reset.

SRST = 0 – no action  
SRST = 1 – start RAM reboot routine

Note: Setting SRST = 1 will NOT result in an ACK, since the part immediately enters the RAM reboot routine. NACK may be used to confirm this command.

**Reserved** – Care must be taken to not overwrite Reset Value of reserved bit(s)

**DCST** – initiates the digital communication self-test function.

DCST = 0 – no action

DCST = 1 – sets DCST\_RESP register to 0xAA and when DCST\_RESP is read, sets this bit to 0 and sets DCST\_RESP to 0x55

**OWUFA, OWUFB, OWUFC** – sets the Output Data Rate for the Wake-Up function (motion detection) per Table 13.

| OWUFA | OWUFB | OWUFC | Output Data Rate |
|-------|-------|-------|------------------|
| 0     | 0     | 0     | 0.781Hz          |
| 0     | 0     | 1     | 1.563Hz          |
| 0     | 1     | 0     | 3.125Hz          |
| 0     | 1     | 1     | 6.25Hz           |
| 1     | 0     | 0     | 12.5Hz           |
| 1     | 0     | 1     | 25Hz             |
| 1     | 1     | 0     | 50Hz             |
| 1     | 1     | 1     | 100Hz            |

**Table 13:** Output Data Rate for Wake-Up Function

|                                                                                   |                                                                           |                                                                                   |
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## INT\_CTRL\_REG1

This register controls the settings for the physical interrupt pin (INT). Note that to properly change the value of this register, the PC1 bit in CTRL\_REG1 must first be set to “0”.

| R/W           | R/W  | R/W  | R/W  | R/W  | R/W  | R/W   | R/W  |             |
|---------------|------|------|------|------|------|-------|------|-------------|
| 0             | 0    | IEN  | IEA  | IEL  | 0    | STPOL | 0    | Reset Value |
| Bit7          | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1  | Bit0 | 00010000    |
| Address: 0x1E |      |      |      |      |      |       |      |             |

**IEN** – enables/disables the physical interrupt pin (INT)

*IEN = 0 – physical interrupt pin (INT) is disabled*

*IEN = 1 – physical interrupt pin (INT) is enabled*

**IEA** – sets the polarity of the physical interrupt pin (INT)

*IEA = 0 – polarity of the physical interrupt pin (INT) is active LOW*

*IEA = 1 – polarity of the physical interrupt pin (INT) is active HIGH*

**IEL** – sets the response of the physical interrupt pin (INT) (see Table 15 for details)

*IEL = 0 – the physical interrupt pin (INT) latches until it is cleared by reading INT\_REL*

*IEL = 1 – the physical interrupt pin (INT) will transmit one pulse with a period of 0.03 - 0.05ms*

**STPOL** – Self-test polarity.

*STPOL = 0 – negative polarity (unsupported)*

*STPOL = 1 – positive polarity (supported)*

## INT\_CTRL\_REG2

This register controls which axis and direction of detected motion can cause an interrupt. Note that to properly change the value of this register, the PC1 bit in CTRL\_REG1 must first be set to “0”.

| R/W           | R/W  | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   |             |
|---------------|------|-------|-------|-------|-------|-------|-------|-------------|
| ULMODE        | 0    | XNWUE | XPWUE | YNWUE | YPWUE | ZNWUE | ZPWUE | Reset Value |
| Bit7          | Bit6 | Bit5  | Bit4  | Bit3  | Bit2  | Bit1  | Bit0  | 00111111    |
| Address: 0x1F |      |       |       |       |       |       |       |             |

**ULMODE** – Unlatched mode motion interrupt (see Table 15 for details)

*ULMOD = 0 – Unlatched mode is disabled*

*ULMOD = 1 – Unlatched mode is enabled*

|                                                                                   |                                                                           |                                                                                   |
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**XNWU** - x negative (x-): 0 = disabled, 1 = enabled  
**XPWU** - x positive (x+): 0 = disabled, 1 = enabled  
**YNWU** - y negative (y-): 0 = disabled, 1 = enabled  
**YPWU** - y positive (y+): 0 = disabled, 1 = enabled  
**ZNWU** - z negative (z-): 0 = disabled, 1 = enabled  
**ZPWU** - z positive (z+): 0 = disabled, 1 = enabled

## DATA\_CTRL\_REG

Read/write control register that configures the acceleration outputs. Note that to properly change the value of this register, the PC1 bit in CTRL\_REG1 must first be set to "0".

| R/W           | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  |             |
|---------------|------|------|------|------|------|------|------|-------------|
| 0             | 0    | 0    | 0    | OSAA | OSAB | OSAC | OSAD | Reset Value |
| Bit7          | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 | 00000010    |
| Address: 0x21 |      |      |      |      |      |      |      |             |

**OSAA, OSAB, OSAC, OSAD** – sets the output data rate (ODR) for the low-pass filtered acceleration outputs per Table 14.

| OSAA | OSAB | OSAC | OSAD | Output Data Rate | LPF Roll-Off |
|------|------|------|------|------------------|--------------|
| 1    | 0    | 0    | 0    | 0.781Hz          | 0.3905Hz     |
| 1    | 0    | 0    | 1    | 1.563Hz          | 0.781Hz      |
| 1    | 0    | 1    | 0    | 3.125Hz          | 1.563Hz      |
| 1    | 0    | 1    | 1    | 6.25Hz           | 3.125Hz      |
| 0    | 0    | 0    | 0    | 12.5Hz           | 6.25Hz       |
| 0    | 0    | 0    | 1    | 25Hz             | 12.5Hz       |
| 0    | 0    | 1    | 0    | 50Hz             | 25Hz         |
| 0    | 0    | 1    | 1    | 100Hz            | 50Hz         |
| 0    | 1    | 0    | 0    | 200Hz            | 100Hz        |
| 0    | 1    | 0    | 1    | 400Hz            | 200Hz        |
| 0    | 1    | 1    | 0    | 800Hz            | 400Hz        |
| 0    | 1    | 1    | 1    | 1600Hz           | 800Hz        |

**Table 14:** Acceleration Output Data Rate (ODR) and LPF Roll-Off

*Note: Output Data Rates ≥ 400Hz will force device into High Resolution mode*

|                                                                                   |                                                                           |                                                                                   |
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## WAKEUP\_COUNTER

This register sets the time motion must be present before a wake-up interrupt is set. Every count is calculated as 1/OWUF delay period. Note that to properly change the value of this register, the PC1 bit in CTRL\_REG1 must first be set to “0”. Valid entries are from 1 to 255, excluding the zero value.

| R/W           | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   |             |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------------|
| WUFC7         | WUFC6 | WUFC5 | WUFC4 | WUFC3 | WUFC2 | WUFC1 | WUFC0 | Reset Value |
| Bit7          | Bit6  | Bit5  | Bit4  | Bit3  | Bit2  | Bit1  | Bit0  | 00000000    |
| Address: 0x29 |       |       |       |       |       |       |       |             |

## NA\_COUNTER

This register sets the non-activity time required before another wake-up interrupt can be set. Every count is calculated as 1/OWUF delay period. Note that to properly change the value of this register, the PC1 bit in CTRL\_REG1 must first be set to “0”. Valid entries are from 1 to 255, excluding the zero value.

| R/W           | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   |             |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------------|
| NAFC7         | NAFC6 | NAFC5 | NAFC4 | NAFC3 | NAFC2 | NAFC1 | NAFC0 | Reset Value |
| Bit7          | Bit6  | Bit5  | Bit4  | Bit3  | Bit2  | Bit1  | Bit0  | 00000000    |
| Address: 0x2A |       |       |       |       |       |       |       |             |

## SELF\_TEST

When 0xCA is written to this register, the MEMS self-test function is enabled. Electrostatic-actuation of the accelerometer, results in a DC shift of the X, Y and Z axes outputs. Writing 0x00 to this register will return the accelerometer to normal operation. Note that to properly change the value of this register, the PC1 bit in CTRL\_REG1 must first be set to “0”.

| W             | W    | W    | W    | W    | W    | W    | W    |             |
|---------------|------|------|------|------|------|------|------|-------------|
| 0             | 0    | 0    | 0    | 0    | 0    | 0    | 0    | Reset Value |
| Bit7          | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 | 00000000    |
| Address: 0x3A |      |      |      |      |      |      |      |             |

## WAKEUP\_THRESHOLD

This register sets the threshold for wake-up (motion detect) interrupt is set. Data bytes are WAKEUP\_THRESHOLD\_H, WAKEUP\_THRESHOLD\_L. The KXTJ3 will be shipped from the factory with this value set to correspond to a change in acceleration of 0.5g. Note that to properly change the value of this register, the PC1 bit in CTRL\_REG1 must first be set to “0”.

| R/W    | R/W    | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | Address | Register           | Reset Value |
|--------|--------|-------|-------|-------|-------|-------|-------|---------|--------------------|-------------|
| WUTH11 | WUTH10 | WUTH9 | WUTH8 | WUTH7 | WUTH6 | WUTH5 | WUTH4 | 0x6A    | WAKEUP_THRESHOLD_H | 00001000    |
| WUTH3  | WUTH2  | WUTH1 | WUTH0 | 0     | 0     | 0     | 0     | 0x6B    | WAKEUP_THRESHOLD_L | 00000000    |
| Bit7   | Bit6   | Bit5  | Bit4  | Bit3  | Bit2  | Bit1  | Bit0  |         |                    |             |

|                                                                                   |                                                                           |                                                                                   |
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## Embedded Applications

### Motion Interrupt

#### Feature Description

KXTJ3 features a threshold interrupts triggered by the internal digital wake-up engine. This engine allows the KXTJ3 to trigger interrupt when accelerometer activity exceeds a threshold window (Wake-Up event). Note that this function only generates an interrupt and doesn't trigger any changes to the part configuration (e.g. power mode, ODR, etc.).

#### Enabling / Disabling

The Wake-up detection can be enabled/disabled using WUFE bit in CTRL\_REG1 register and the direction of motion detection can be set for any axis in INT\_CTRL\_REG2 register. The sampling rate for the Wake-Up function is independent of the output data rate of the KXTJ3 and is set by OWUF bits in CTRL\_REG2.

#### Latched / Pulsed / Unlatched Interrupt Modes

The wake-up event can be programmed to be reported on physical interrupt pin INT. There are three supported modes that are configured using IEL bit in CTRL\_REG2 register and ULMODE bit in INT\_CTRL\_REG2 register. The modes are Latched, Pulsed, and Unlatched. Depending on the interrupt mode, the behavior of the external interrupt pin INT, the wake-up function status bit WUFS in INT\_SOURCE1 register, the interrupt report bit INT in STATUS\_REG, and corresponding motion direction detection bit (XNWU / XPWU / YNWU / YPWU / ZNWU / ZPWU) in the INT\_SOURCE2 registers will be different.

| ULMODE | IEL | Interrupt Mode | External INT Pin                                         | INT bit and WUFS bit                                       | XNWU / XPWU / YNWU / YPWU / ZNWU / ZPWU                                   |
|--------|-----|----------------|----------------------------------------------------------|------------------------------------------------------------|---------------------------------------------------------------------------|
| 0      | 0   | Latched        | INT pin latches until INT_REL is read                    | INT and WUFS bit are 1 until INT_REL is read               | The corresponding motion directions bit is set to 1 until INT_REL is read |
| 0      | 1   | Pulsed         | INT pin is pulsed @ 0.03-0.05 ms                         | INT and WUFS bit are 1 until INT_REL is read               | The corresponding motion directions bit is set to 1 until INT_REL is read |
| 1      | 0   | Unlatched      | INT pin is pulsed and automatically cleared after 1/OWUF | INT bit and WUFS bit are 1 until auto-cleared after 1/OWUF | The corresponding motion directions bit is set to 1 until INT_REL is read |
| 1      | 1   | Pulsed         | INT pin is pulsed @ 0.03-0.05 ms                         | INT bit and WUFS bit are 1 until auto-cleared after 1/OWUF | The corresponding motion directions bit is set to 1 until INT_REL is read |

**Table 15:** Latched / Pulsed / Unlatched Interrupt Modes Configuration

|                                                                                   |                                                                           |                                                                                   |
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## Debounce Counter

The Wake-Up digital engine has an internal debounce counter to qualify motion status detection. The debounce counter function can be set using WUFC<7:0> bits in WAKEUP\_COUNTER register. Note that each Wake-Up Function Counter (WUFC) count qualifies 1 (one) user-defined Wake-Up Function ODR period as set by OWUF<2:0> bits in CTRL\_REG2 register. Equation 1 shows how to calculate the WAKEUP\_COUNTER register value for a desired wake-up delay time.

$$WAKEUP\_COUNTER \text{ (counts)} = \text{Wake-Up Delay Time (sec)} \times \text{Wake-Up Function ODR (Hz)}$$

**Equation 1:** Wake-Up Delay Time Calculations

## Non-Activity Counter

The Non-Activity register sets the non-activity time required before another wake-up interrupt will be reported. The non-activity counter function can be set using NAFC7<7:0> bits in NA\_COUNTER register. Note that each Non-Activity Function Counter (NAFC) count qualifies 1 (one) user-defined Wake-Up Function ODR period as set by OWUF<2:0> bits in CTRL\_REG2 register. Equation 2 shows how to calculate the WAKEUP\_COUNTER register value for a desired wake-up delay time.

$$NA\_COUNTER \text{ (counts)} = \text{Non-Activity Time (sec)} \times \text{Wake-Up Function ODR (Hz)}$$

**Equation 2:** Non-Activity Counter Calculations

## Threshold Resolution

The motion interrupt threshold values are set by WUTH<11:0> bits in the WAKEUP\_THRESHOLD registers and are compared to the top 12 bits of the accelerometer 8g output value (regardless of GSEL<1:0> setting in CTRL\_REG1 register). This results in threshold resolution of 256 counts/g or 3.9mg/count

## Threshold Calculations

To calculate the desired wake-up threshold use Equation 3. Please note that the wake-up engine function is independent of the user selected g-range.

$$WAKEUP\_THRESHOLD \text{ (counts)} = \text{Desired Threshold (g)} \times 256 \text{ (counts/g)}$$

**Equation 3:** Wake-Up Threshold Calculations

|                                                                                   |                                                                           |                                                                                   |
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## Wake-Up Detection Example

The latched motion interrupt response algorithm works as following: while the part is in inactive state, the algorithm evaluates differential measurement between each new acceleration data point with the preceding one and evaluates it against the WAKEUP\_THRESHOLD threshold. When the differential measurement is greater than WAKEUP\_THRESHOLD threshold, the wakeup counter starts the count. Differential measurements are now calculated based on the difference between the current acceleration and the acceleration when the counter started. The part will report that motion has occurred at the end of the count assuming each differential measurement has remained above the threshold. If at any moment during the count the differential measurement falls below the threshold, the counter will stop the count and the part will remain in inactive state.

To illustrate how the algorithm works, consider the Figure 4 below that shows the latched response of the motion detection algorithm with WAKEUP\_COUNTER set to 10 counts. Note how the difference between the acceleration sample marked in red and the one marked in green resulted in a differential measurement represented with orange bar being above the WAKEUP\_THRESHOLD. At this point, the counter begins to count number of counts stored in WAKEUP\_COUNTER register and the wakeup algorithm will evaluate the difference between each new acceleration measurement and the measurement marked in green that will remain a reference measurement for the duration of the counter count. At the end of the count, assuming all differential measurements were larger than WAKEUP\_THRESHOLD, as is the case in the example showed in Figure 4, a motion event will be reported. Figure 4 below shows the latched response of the Wake-Up Function with WUF counter = 10 counts.



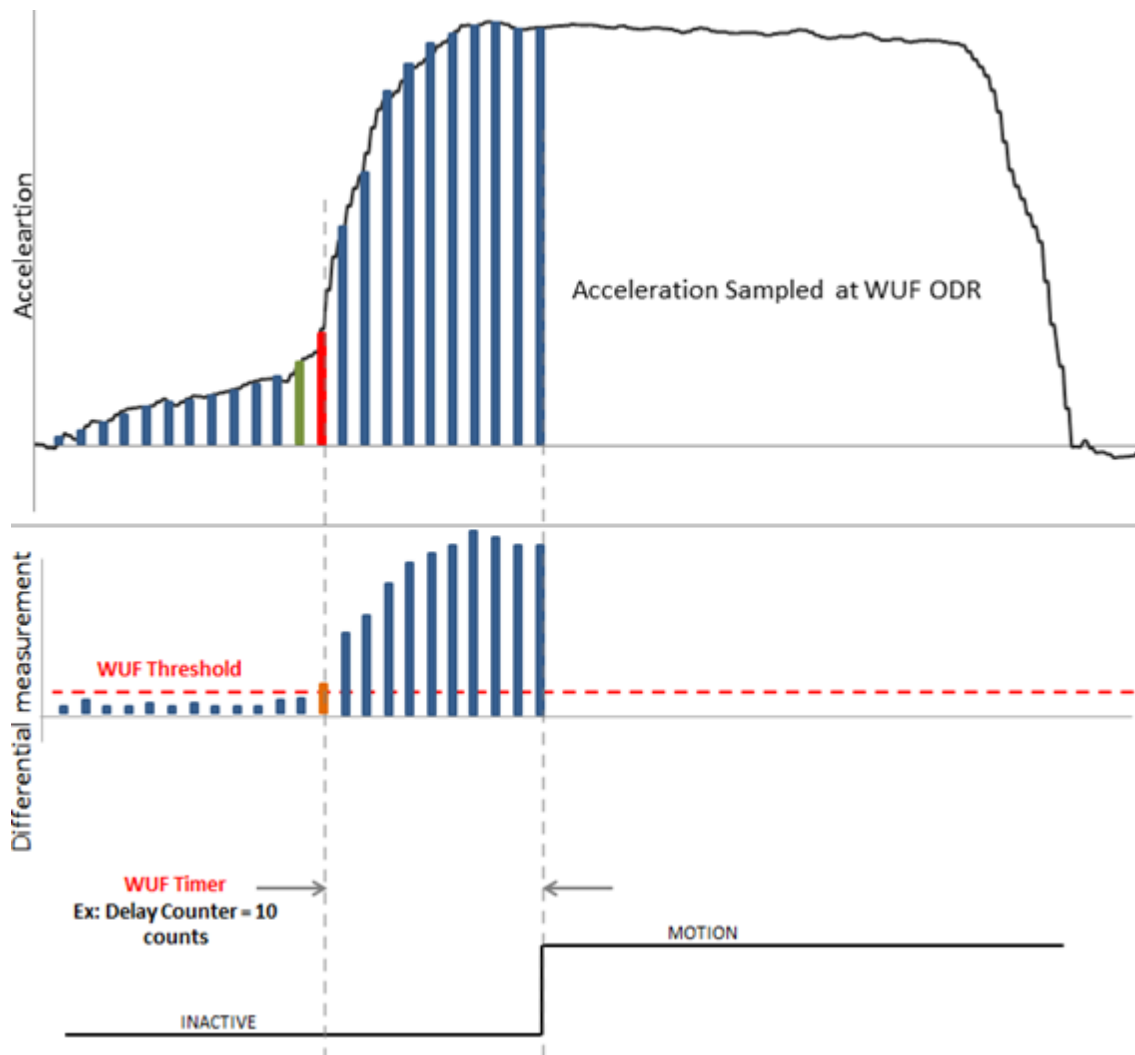
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**Rev. 4.0**

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**Figure 4: Latched Motion Interrupt Response**

|                                                                                   |                                                                           |                                                                                   |
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## Revision History

| Revision | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Date        |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| 1.0      | Initial Release                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 08-Nov-2016 |
| 2.0      | Clarified 14bit/12bit/8bit operation throughout the document.<br>Updated Notice section.<br>Clarified Wake Up register naming.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 10-Nov-2016 |
| 3.0      | Fixed Pin number of physical interrupt pin in INT_CTRL_REG1 and INT_REL registers to (5) from (7).<br>Added Appendix section.<br>Added drive type for INT pin in Pin Description Table.<br>Updated IO VDD max value in Electrical Specifications.                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 27-Sep-2017 |
| 4.0      | Updated note under the Electrical Spec that Start Up timing also varies with power mode.<br>Removed Signal Bandwidth (-3dB) from Mechanical Specification.<br>Update Start Up Timing Figure.<br>Updated Environmental section.<br>Updated I2C Operation section to add support for alternative I2C address.<br>Updated Package Outline Drawing.<br>Updated Handling, Mounting, Soldering and Floor Life sections.<br>Updated I2CFixed Reg 0x6B name in Register Map (WAKEUP_THRESHOLD_L).<br>Updated description of WUFS, INT, RES, SRST, IEL, ULMODE bits.<br>Updated description of INT_SOURCE2, INT_REL, WAKEUP_THRESHOLD, SELF_TEST registers.<br>Updated Embedded Wake-Up Function engine description. | 05-Oct-2018 |

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## Appendix

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