# STK8BA58

## Digital Output 3-axis MEMS Accelerometer

## Datasheet

Version – 1.0

2019/11/26

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# 1. OVERVIEW

## Description

The STK8BA58 is a ±2g/±4g/±8g, 3-axis linear accelerometer, with digital output ($I^2C$). It is a low profile capacitive MEMS sensor featuring, compensation for 0g offset and gain errors, and conversion to 12-bit digital values at user configurable samples per second. The device can be arranged for sensor data changes through the interrupt pins. The STK8BA58 is available in a small 2.0mm x 2.0mm x 1.0 mm LGA package and it is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

## Feature

- Low Voltage Operation:
  - Supply Internal Domain Voltage: 1.7V~3.6V
  - I/O Voltage Range: 1.62V~3.6V
- ±2g/±4g±/8g dynamically selectable full-scale
- $I^2C$ digital output interface
- Low noise
- 12 bit data output
- 10000 g high shock survivability
- 2.0mm x 2.0mm x 1.0 mm LGA Package
- Configurable Samples from 14 to 2000 samples per second
- Sleep Feature for Low Power Consumption
- On-chip interrupt controller, motion-triggered interrupt-signal generation for
  - New data
  - Any-motion (slope) detection
  - Significant motion
- RoHS Compliant
- Halogen Free
- Environmentally Preferred Product
- Moisture Sensitivity Level 3

## Applications

- Display orientation
- Gaming and virtual reality input devices
- Impact recognition and logging
- Vibration monitoring and compensation
- Pedometer
- Activity trackers for fitness apps
- Smart power management for mobile devices

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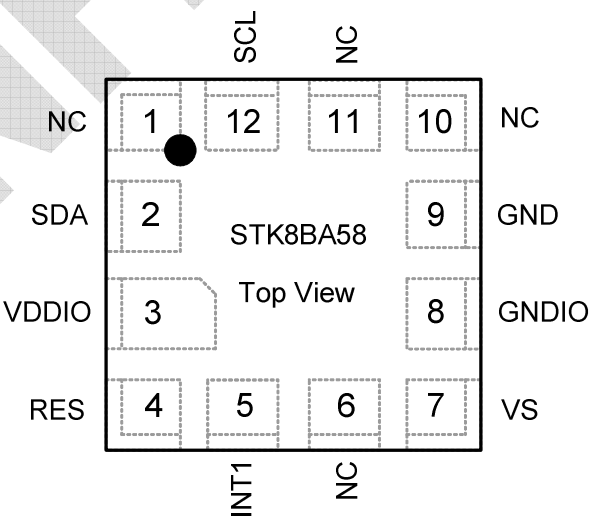
# 2. PIN DESCRIPTION

| Pin# | Name | Dir. | Function |
|---|---|---|---|
| 1 | NC | NC | Not Internally Connected. |
| 2 | SDA | B | Serial Data ($I^2C$, Open-Drain) |
| 3 | VDDIO | PWR | Digital Interface Supply Voltage. |
| 4 | Reserved | I | Recommended tie to GND. |
| 5 | INT1 | O | Interrupt 1 Output. |
| 6 | NC | NC | Not Internally Connected. |
| 7 | VS | PWR | Supply Voltage. |
| 8 | GNDIO | GND | Must be connected to ground. |
| 9 | GND | GND | Must be connected to ground. |
| 10 | NC | NC | Not Internally Connected. |
| 11 | NC | NC | Not Internally Connected. |
| 12 | SCL | I | Serial Communications Clock ($I^2C$, Open-Drain) |

Direction denotation:

| | | | |
|---|---|---|---|
| O | Output | GND | Ground |
| I | Input | B | Bi-direction |
| PWR | Power | NC | Not Connected |

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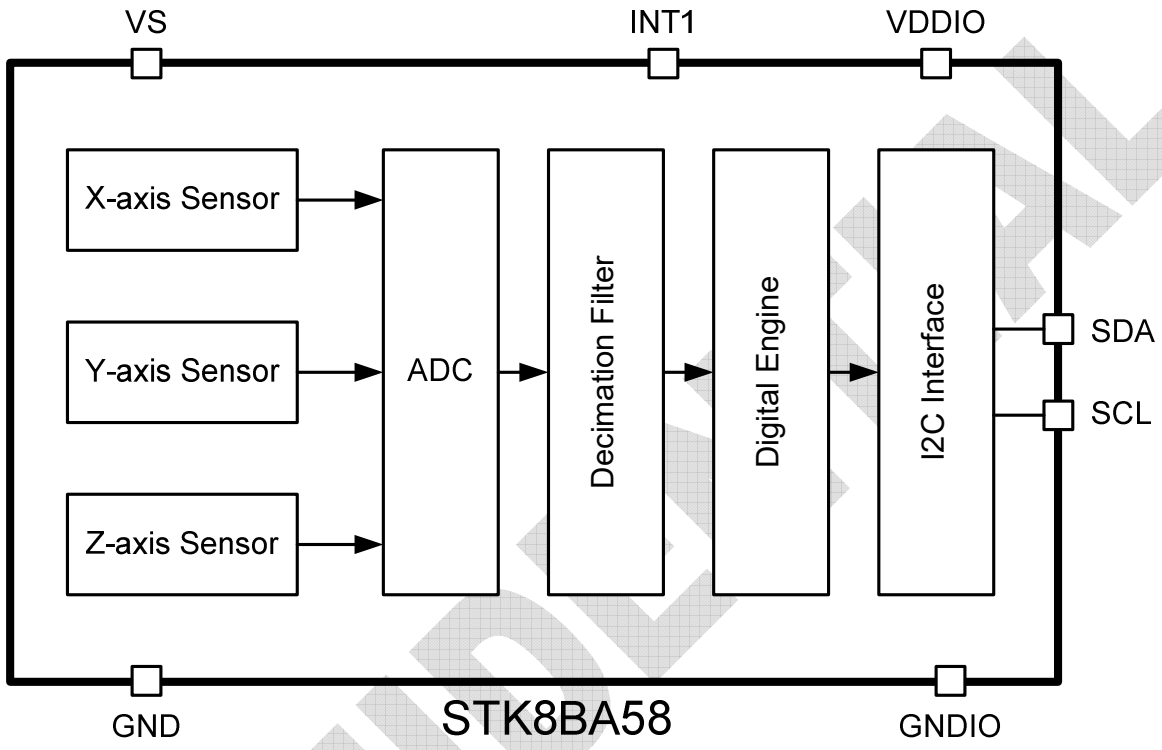
# 3. FUNCTION BLOCK

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# 4. ELECTRICAL SPECIFICATIONS

$T_A$ = 25°C, VS = 2.6 V, VDDIO = 2.6 V, acceleration = 0 *g*, $C_S$ = $C_{I/O}$ = 10 µF and 0.1 µF

| Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| POWER SUPPLY | | | | | |
| Operating Voltage Range (VS) | | 1.7 | 2.6 | 3.6 | V |
| Interface Voltage Range (VDDIO) | | 1.62 | 2.6 | 3.6 | V |
| Current consumption in normal mode | | | 110 | | µA |
| Current consumption in suspend mode | | | 1 | | µA |
| Current consumption in low-power mode | Sleep duration=25 ms<br>Bandwidth=1k Hz | | 7 | | uA |
| Start-Up Time | POR<br>Bandwidth=1k Hz | | 3 | | ms |
| Digital high level input voltage (VIH) | | 0.7 x VDDIO | | | V |
| Digital low level input voltage (VIL) | | | | 0.3 x VDDIO | V |
| High level output voltage (VOH)[1] | | 0.8 x VDDIO | | | V |
| Low level output voltage (VOL)[1] | | | | 0.2 x VDDIO | V |
| OUTPUT DATA RATE AND BANDWIDTH | Each axis | | | | |
| Bandwidth (BW) | | | 7.81 | | Hz |
| | | | 15.63 | | Hz |
| | | | 31.25 | | Hz |
| | | | 62.5 | | Hz |
| | | | 125 | | Hz |
| | | | 250 | | Hz |
| | | | 500 | | Hz |
| | | | 1000 | | Hz |
| Output data rate (ODR) in normal mode | | | BW * 2 | | Hz |

1. IOL = 10mA, IOH = -4mA

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# 5. MECHANICAL SPECIFICATIONS

$T_A$ = 25°C, VS = 2.6 V, VDDIO = 2.6 V, acceleration = 0 *g*, $C_S$ = $C_{I/O}$ = 10 µF and 0.1 µF

| Parameter | Test Conditions | Min | Typical | Max | Unit |
|---|---|---|---|---|---|
| SENSOR INPUT | Each axis | | | | |
| Measurement Range | User selectable | | ±2, ±4, ±8 | | g |
| Non-linearity | Percentage of full scale | | ±0.5 | | %FS |
| Cross-Axis Sensitivity | | | 1 | | % |
| OUTPUT RESOLUTION | Each axis | | | | |
| ±2 g Range | Full resolution | | 12 | | Bits |
| ±4 g Range | Full resolution | | 12 | | Bits |
| ±8 g Range | Full resolution | | 12 | | Bits |
| SENSITIVITY | Each axis | | | | |
| Sensitivity at XOUT, YOUT, ZOUT | ±2g, 12-bit resolution | | 1024 | | LSB/g |
| | ±4g, 12-bit resolution | | 512 | | LSB/g |
| | ±8g, 12-bit resolution | | 256 | | LSB/g |
| Sensitivity Change Due to Temperature | X-, Y-, Z-Axes | | ±0.02 | | %/°C |
| 0 g OFFSET[1] | Each axis | | | | |
| 0 g Output for XOUT, YOUT, ZOUT | | | ±100 | | mg |
| 0 g Offset Change Due to Temperature | X-, Y-, Z-Axes | | ±1 | | mg/°C |
| NOISE | | | | | |
| X-, Y-, Z-Axes | ±2g, 12-bit resolution<br>Bandwidth = 1k Hz | | 200 | | µg/sqrt(Hz) |

1. These parameters are tested in production at final test, and could slightly change after mounting the sensor onto a printed circuit board or exposing it to extensive mechanical stress.

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# 6. ABSOLUTE MAXIMUM RATINGS

| Symbol | Ratings | Maximum value | Unit |
|---|---|---|---|
| VS | Supply voltage | -0.3 to 3.6 | V |
| VDDIO | Digital Interface Supply Voltage | -0.3 to 3.6 | V |
| Vin | Input voltage on any control pin | -0.3 to 3.6 | V |
| $A_{UNP}$ | Acceleration (any axis, unpowered) | 10000 | g |
| $T_{OP}$ | Operating temperature range | -40 to +85 | °C |
| $T_{STG}$ | Storage temperature range | -40 to +125 | °C |
| ESD | Electrostatic discharge protection | 2 (HBM) | kV |
| | | 500 (CDM) | V |
| | | 200 (MM) | V |
| | | 100 (Latch Up) | mA |

# 7. DIGITAL INTERFACE

$I^2C$ digital interface are available in STK8BA53. In the cases, the STK8BA58 operates as a slave device.

## 7.1 $I^2C$

All registers in STK8BA58 can be accessed via the $I^2C$ bus. All operations can be controlled by the related registers. There are two signals associated with the $I^2C$ bus: the serial clock line (SCL) and the serial data line (SDA). The latter is a bidirectional signal used for sending and receiving the data to/from the interface. Both signals are pull-up to $V_{DD\ I/O}$ through an external resistor.

A watchdog timer (WDT) is used to prevent the $I^2C$ bus lock-up by STK8BA53. The $I^2C$ bus will be reset and return to normal operation state once the WDT is reached. The WDT can be enabled/disabled by I2C_WDT_EN bit and the timer period can be set by I2C_WDT_SEL bit in register INTFCFG (0x34).

The STK8BA58 $I^2C$ command format description for reading and writing operation between the host and STK8BA58 are shown in the following timing chart.

### Slave Address

| Slave Address (7-bit) | R/W Command Bit | OPERATION |
|---|---|---|
| 0x18 | 0 | Write Data to STK8BA53 |
| | 1 | Read Data form STK8BA53 |

### Characteristics of the $I^2C$ Timing

| Symbol | Parameter | Standard Mode | | Fast Mode | | Unit |
|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | |
| $f_{SCLK}$ | SCL clock frequency | 10 | 100 | 10 | 400 | KHz |
| $t_{HDSTA}$ | Hold time after (repeated) start condition. After this period, the first clock is generated | 4.0 | — | 0.6 | — | µs |
| $t_{LOW}$ | LOW period of the SCL clock | 4.7 | — | 1.3 | — | µs |

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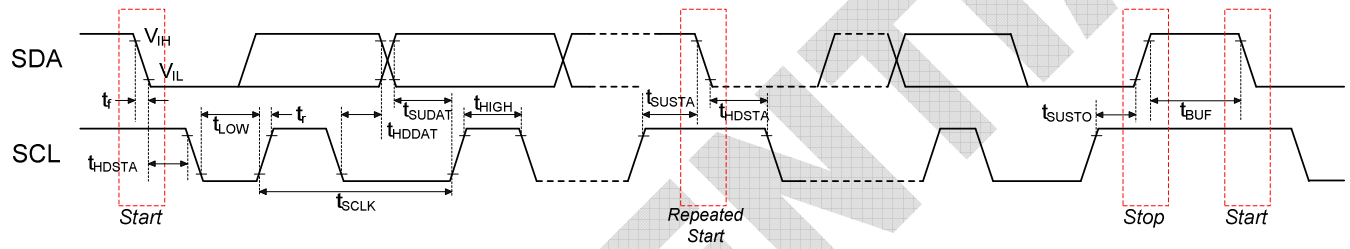
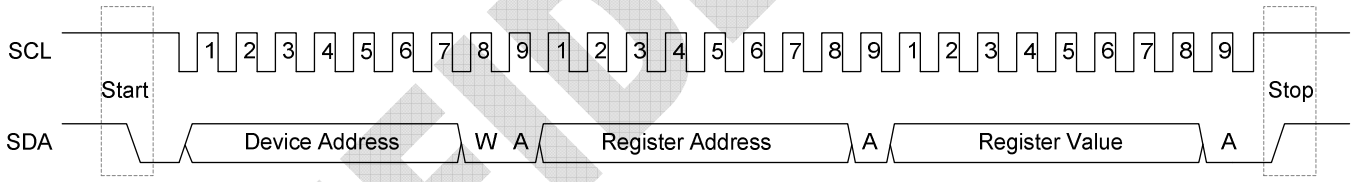
| | | | | | | |
|---|---|---|---|---|---|---|
| $t_{HIGH}$ | HIGH period of the SCL clock | 4.0 | — | 0.6 | — | μs |
| $t_{SUSTA}$ | Set-up time for a repeated START condition | 4.7 | — | 0.6 | — | μs |
| $t_{HDDAT}$ | Data hold time | 0 | — | 0 | — | ns |
| $t_{SUDAT}$ | Data set-up time | 250 | — | 100 | — | ns |
| $t_r$ | Rise time of both SDA and SCL signals | — | 1000 | — | 300 | ns |
| $t_f$ | Fall time of both SDA and SCL signals | — | 300 | — | 300 | ns |
| $t_{SUSTO}$ | Set-up time for STOP condition | 4.0 | — | 0.6 | — | μs |
| $t_{BUF}$ | Bus free time between a STOP and START condition | 4.7 | — | 1.3 | — | μs |

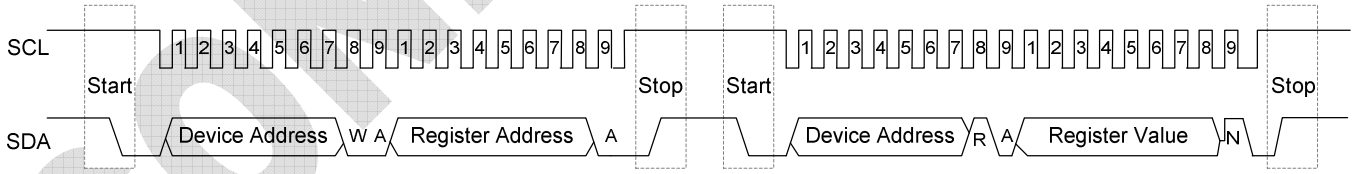
Note: $f_{SCLK}$ is the $(t_{SCLK})^{-1}$.



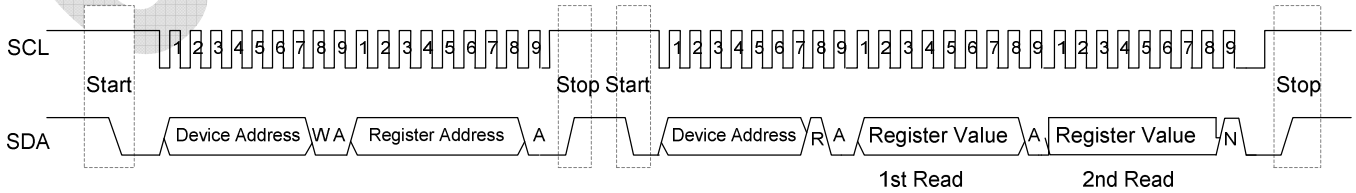

**Timing Chart of the I²C**




**Write Command**




**Read Data**




**Sequential Read Data**

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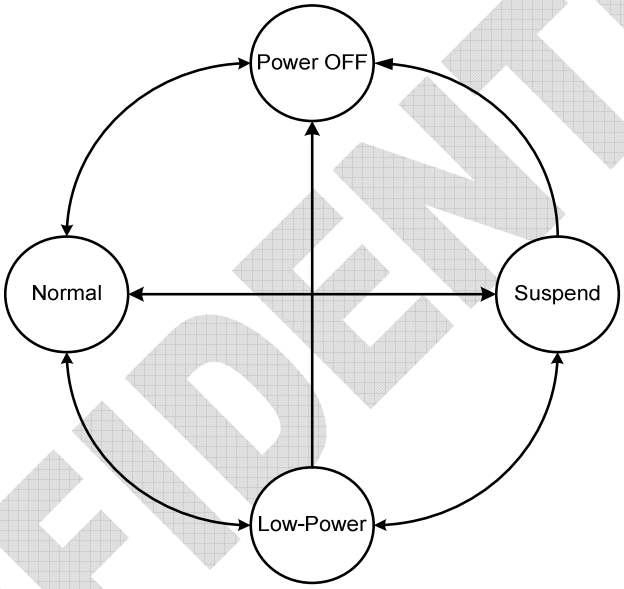
# 8. PRINPICLE OF OPERATION

## 8.1 Mode of Operation

STK8BA58 acts as a slave and can communicate with a master (uC or uP). Acceleration data and status information can be accessed with $I^2C$ interface. The interrupt pin are freely configured by user, depends on different requirements.

## 8.2 Power Management

STK8BA58 has three different power modes, Normal Mode, Low-Power Mode and Suspend Mode. After power-on, it will enter Normal Mode, and user can transfer to Low-Power Mode or Suspend Mode for power-saving purpose.




In **Normal Mode**, all functions are available and data acquisition is performed continuously.

In **Suspend Mode**, whole analog and oscillator are power-down. No data acquisition is performed. Only register reading and writing to SUSPEND bit in register POWMODE (0x11) or register SWRST (0x14) are supported. Suspend mode can be entered by set SUSPEND bit in register POWMODE (0x11) to 1. In the suspend mode, the output data doesn't clear or update, but keeps the last value before entering into suspend mode.

In **Low-Power Mode**, STK8BA58 will switch between wake-up and sleep phase. In wake-up phase, the device is full functional operation, just like in Normal Mode, and in sleep phase, the analog circuit is power-down except oscillator. During the wake-up phase, enabled interrupts are processed normally. If an interrupt is detected, device will stay in wake-up phase as long as the interrupt condition endures (non-latched interrupt), or until the latch time expires (temporary interrupt), or until the interrupt is reset (latched interrupt). If no interrupt is detected, the device enters the sleep phase automatically. Average current consumption can be effectively reduced by entering low-power mode. Low-power mode can be entered by setting LOWPOWER bit in register POWMODE (0x11) to 1.

The duration of sleep phase can be set by SLEEP_DUR [3:0] in register POWMODE (0x11).

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| SLEEP_DUR[3:0] | Duration (ms) | Actually ODR with 1kHz bandwidth (Hz) |
|---|---|---|
| 4'b0000 ~ 4'b0101 | 0.5 | 295 |
| 4'b0110 | 1 | 255 |
| 4'b0111 | 2 | 202 |
| 4'b1000 | 4 | 140 |
| 4'b1001 | 6 | 110 |
| 4'b1010 | 10 | 75 |
| 4'b1011 | 25 | 34 |
| 4'b1100 | 50 | 18 |
| 4'b1101 | 100 | 10 |
| 4'b1110 | 500 | 2 |
| 4'b1111 | 1000 | 1 |

## 8.3 Data, Range and Bandwidth

### Acceleration Data

The acceleration data of STK8BA58 is 12 bit and is given in two's complement format. The MSB in each axis will be stored in register XOUT2/YOUT2/ZOUT2 (0x03, 0x05, 0x07) individually, and the LSB will be stored in register XOUT1/YOUT1/ZOUT1 (0x02, 0x04, 0x06) individually. The NEW_X/NEW_Y/NEW_Z bit in register XOUT1/YOUT1/ZOUT1 (0x02, 0x04, 0x06) is used for new data flag, and it will be set to 1 if the data is updated, and reset if either the corresponding MSB or LSB is read. Reading the acceleration data registers shall always start with the LSB part due to the data protection function. When data protection function is enabled, the content of an MSB register will be updated by reading the corresponding LSB register. The data protection function can be disabled (enabled) by writing '1' ('0') to the PROTECT_DIS bit in register DATASETUP (0x13). With disabled data protection, the content of both MSB and LSB registers is updated by a new value immediately.

### Range

The STK8BA58 supports four different acceleration measurement ranges. A measurement range can be selected by RANGE[3:0] bits in register RANGESEL (0x0F).

| RANGE[3:0] | Sensing Range | Resolution |
|---|---|---|
| 4'b0011 | ±2g | 0.98 mg/LSB |
| 4'b0101 | ±4g | 1.95 mg/LSB |
| 4'b1000 | ±8g | 3.91 mg/LSB |
| others | undefined | undefined |

### Bandwidth

There are two different data stream of STK8BA53, unfiltered data and filtered data. Unfiltered data is sampled as 2 kHz, and the sample rate of filtered data depends on the selected bandwidth; it is twice of the bandwidth. If the DATA_SEL bit in register DATASETUP (0x13) is set to '0' ('1'), the filtered (unfiltered) data will be stored in the XOUT/YOUT/ZOUT data register. Each of the data stream can be separately offset-compensated, and also can be the data source of interrupts controller. The actual bandwidth for the filtered data can be selected by BW [4:0] bits in register BWSEL (0x10).

| BW[4:0] | Actual Bandwidth (Hz) |
|---|---|
| 5'b00xxx | 7.81 |
| 5'b01000 | 7.81 |
| 5'b01001 | 15.63 |
| 5'b01010 | 31.25 |
| 5'b01011 | 62.5 |
| 5'b01100 | 125 |
| 5'b01101 | 250 |
| 5'b01110 | 500 |
| 5'b01111 | 1000 |
| 5'b1xxxx | 1000 |

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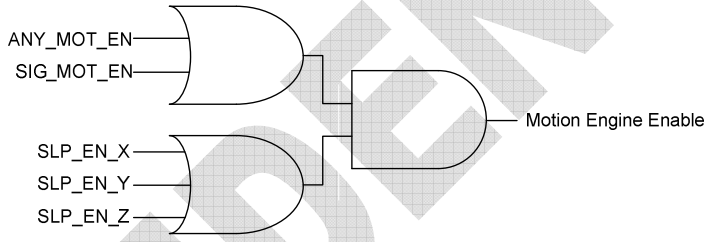
## 8.4 Motion Algorithm Status and Interrupt Event Detection

The following table shows the interrupt events offered by STK8BA53. Two interrupt engines and one INT pins are integrated for conveniently motion detection. Each interrupt could be enabled independently, and mapped into the INT pin. If the condition of enabled interrupt is fulfilled, the corresponding status is set to '1' and the INT pin is asserted. The INT pin state is logical 'or' combination of all mapped interrupts. The INT pin state is logical 'or' combination of all mapped interrupts. If an interrupt is disabled, all active pins and status are reset immediately.

Two motion algorithms, any-motion and significant motion, used for detecting user movement can flexibly choose three independent axes as the data source via register INTEN1 (0x16), and the event signal is triggered by an "OR" combination of the enabled axes.

| Interrupt Event | Control Bit | Status Bit in Register INTSTS1/2 (0x09, 0x0A) |
|---|---|---|
| New Data | DATA_EN in INTEN2 (0x17) | DATA_STS |
| Any-Motion (Slope)<br>Significant Motion | SLP_EN_Z in INTEN1 (0x16)<br>SLP_EN_Y in INTEN1 (0x16)<br>SLP_EN_X in INTEN1 (0x16)<br>ANY_MOT_EN in SIGMOT2 (0x2A)<br>SIG_MOT_EN in SIGMOT2 (0x2A) | ANY_MOT_STS<br>SIG_MOT_STS |
| | | ANY_MOT_STS |
| | | SIG_MOT_STS |

Note: Motion algorithm engine follows the logic shown below.




### Interrupt Latch Mode

There are three different interrupt latch modes of Any-Motion (Slope) and Significant Motion: non-latched, temporary, and latched. The modes can be selected by the INT_LATCH [3:0] bits in register INTCFG2 (0x21). The following table shows the different configurations of interrupt modes in INT_LATCH [3:0].

*Note: Interrupt latched mode INT_LATCH [3:0] in register INTCFG2 (0x21) can not be default setting after motion algorithms enabled. Interrupt latched mode must be set in the initial configuration.*

| INT_LATCH[3:0] | Output Mode |
|---|---|
| 4'b0000 | non-latched |
| 4'b0001 | temporary, 250ms |
| 4'b0010 | temporary, 500ms |
| 4'b0011 | temporary, 1s |
| 4'b0100 | temporary, 2s |
| 4'b0101 | temporary, 4s |
| 4'b0110 | temporary, 8s |
| 4'b0111 | latched |
| 4'b1000 | non-latched |
| 4'b1001 | temporary, 250us |
| 4'b1010 | temporary, 500us |
| 4'b1011 | temporary, 1ms |
| 4'b1100 | temporary, 12.5ms |
| 4'b1101 | temporary, 25ms |
| 4'b1110 | temporary, 50ms |
| 4'b1111 | latched |

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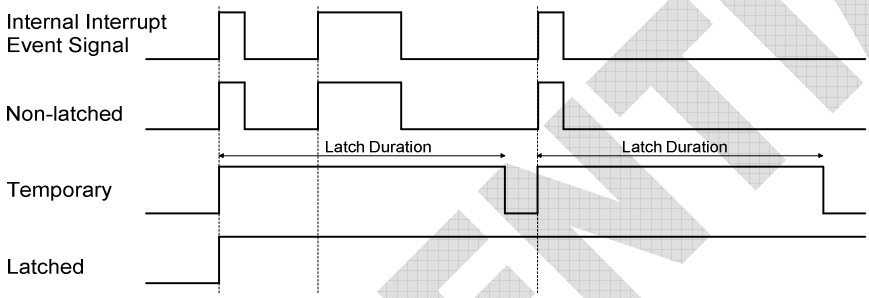
In the **non-latched mode**, the corresponding status and mapped INT pin are clear as soon as the activation condition is no more valid.

In the **latched mode**, the status and mapped INT pins are cleared only by setting '1' to the INT_RST bit in register INTCFG2 (0x21). If the activation condition still holds when it is cleared, the interrupt pin and status will be both asserted again.

In the **temporary mode**, an asserted interrupt and selected pin are cleared after a defined period of time. The following figure shows the behavior of three interrupt modes.

Both filtered and unfiltered data could be the data source of the interrupt events. Setting the corresponding bit in register DATASETUP (0x13) to '0'('1') will select the filtered(unfiltered) data as the data source for interrupt events.




Interrupt latch mode control bits only apply to Any-Motion (Slope) and Significant Motion. Other interrupt events are fixed to their own latch mode, which are shown in the following table.

| Interrupt Event | Type | Latch mode | Clear |
|---|---|---|---|
| New data | Status | Non-latch | Auto clear after 250us |
| Any-Motion (Slope) | Programmable | Programmable | Based on configuration |
| Significant Motion | Programmable | Programmable | Based on configuration |

### Interrupt Pin Mapping

The mapping of interrupts to the INT1 is controlled by registers INTMAP2 (0x1A). Setting the corresponding bit to '1'('0') maps(un-maps) the related interrupt to the INT1 pin.

### INT Pin Output Type and Active Level

INT1 could be configured as Push-Pull/Open-Drain output and the active level could also be set as active-high/activelow. The related bits in register INTCFG1 (0x20) are used to select the INT1 output type and active level.

## 8.5 Offset Compensation

### Manual Compensation

STK8BA58 offers the manual digital offset-compensation method. It is done by adding a compensation value to the acceleration data coming from the ADC. The registers OFSTX/Y/Z (0x38, 0x39, 0x3A) are used to for the offset compensation purpose and are given in two's complement format. 1 LSB of OFSTX/Y/Z represents 7.81mg in any sensing range.

By writing '1' to the OFST_RST bit in register OFSTCOMP1 (0x36), all offset compensation registers are reset to zero.

It is recommended to write into these registers immediately after a new data interrupt in order not to disturb running offset computations.

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# 9. REGISTER DEFINATION

## 9.1 Register Map

| ADDR | REG NAME | BIT 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Default |
|---|---|---|---|---|---|---|---|---|---|---|
| 00h | CHIP_ID | CHIP_ID[7:0] | | | | | | | | 87h |
| 01h | RESERVED | reserved | | | | | | | | 00h |
| 02h | XOUT1 | XOUT[3:0] | | | | reserved | | | NEW_X | 00h |
| 03h | XOUT2 | XOUT[11:4] | | | | | | | | 00h |
| 04h | YOUT1 | YOUT[3:0] | | | | reserved | | | NEW_Y | 00h |
| 05h | YOUT2 | YOUT[11:4] | | | | | | | | 00h |
| 06h | ZOUT1 | ZOUT[3:0] | | | | reserved | | | NEW_Z | 00h |
| 07h | ZOUT2 | ZOUT[11:4] | | | | | | | | 00h |
| 08h | RESERVED | reserved | | | | | | | | 00h |
| 09h | INTSTS1 | reserved | | | | | ANY_MOT_STS | reserved | SIG_MOT_STS | 00h |
| 0Ah | INTSTS2 | DATA_STS | reserved | | | | | | | 00h |
| 0Bh | EVENTINFO1 | reserved | SLPSIGN_Z | SLPSIGN_Y | SLPSIGN_X | reserved | SLP_1ST_Z | SLP_1ST_Y | SLP_1ST_X | 00h |
| 0Ch-0Eh | RESERVED | reserved | | | | | | | | 00h |
| 0Fh | RANGESEL | reserved | | | | RANGE[3:0] | | | | 03h |
| 10h | BWSEL | reserved | | | BW[4:0] | | | | | 1Fh |
| 11h | POWMODE | SUSPEND | LOWPOWER | reserved | SLEEP_DUR[3:0] | | | | reserved | 00h |
| 12h | RESERVED | reserved | | | | | | | | 00h |
| 13h | DATASETUP | DATA_SEL | PROTECT_DIS | reserved | | | | | | 00h |
| 14h | SWRST | SWRST[7:0] | | | | | | | | 00h |
| 15h | RESERVED | reserved | | | | | | | | 00h |
| 16h | INTEN1 | reserved | | | | | SLP_EN_Z | SLP_EN_Y | SLP_EN_X | 00h |
| 17h | INTEN2 | reserved | | | DATA_EN | reserved | | | | 00h |
| 18h | RESERVED | reserved | | | | | | | | 00h |
| 19h | INTMAP1 | reserved | | | | | ANYMOT2INT1 | reserved | SIGMOT2INT1 | 00h |
| 1Ah | INTMAP2 | reserved | | | | | | | DATA2INT1 | |
| 1Bh-1Fh | RESERVED | reserved | | | | | | | | 00h |
| 20h | INTCFG1 | reserved | | | | | | INT1_OD | INT1_LV | 01h |
| 21h | INTCFG2 | INT_RST | reserved | | | INT_LATCH[3:0] | | | | 00h |
| 22h-26h | RESERVED | reserved | | | | | | | | 00h |
| 27h | SLOPEDLY | reserved | | | | | | SLP_DUR[1:0] | | 00h |
| 28h | SLOPETHD | SLP_THD[7:0] | | | | | | | | 14h |
| 29h | SIGMOT1 | SKIP_TIME[7:0] | | | | | | | | 96h |
| 2Ah | SIGMOT2 | reserved | | | | | ANY_MOT_EN | SIG_MOT_EN | SKIP_TIME[8] | 02h |
| 2Bh | SIGMOT3 | reserved | PROOF_TIME[6:0] | | | | | | | 32h |
| 2Ch-33h | RESERVED | reserved | | | | | | | | 00h |
| 34h | INTFCFG | reserved | | | | | I2C_WDT_EN | I2C_WDT_SEL | reserved | 00h |
| 35h | RESERVED | reserved | | | | | | | | 00h |
| 36h | OFSTCOMP1 | OFST_RST | reserved | | | | | | | 00h |


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| | | | |
|---|---|---|---|
| **37h** | RESERVED | reserved | **00h** |
| **38h** | OFSTX | OFST_X[7:0] | **00h** |
| **39h** | OFSTY | OFST_Y[7:0] | **00h** |
| **3Ah** | OFSTZ | OFST_Z[7:0] | **00h** |

## 9.2 Register Description

### CHIP_ID Register (00h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| CHIP_ID[7:0] | | | | | | | |
| 8'b10000111 | | | | | | | |
| RO | | | | | | | |

The register contains the chip identification code.

### XOUT1 Register (02h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| XOUT[3:0] | | | | reserved | | | NEW_X |
| 4'b0000 | | | | 3'b000 | | | 0 |
| RO | | | | RO | | | RO |

XOUT1/XOUT2 register contain the x-axis acceleration data and the new data flag for the x-axis.

### XOUT2 Register (03h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| XOUT[11:4] | | | | | | | |
| 8'b00000000 | | | | | | | |
| RO | | | | | | | |

### YOUT1 Register (04h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| YOUT[3:0] | | | | reserved | | | NEW_Y |
| 4'b0000 | | | | 3'b000 | | | 0 |
| RO | | | | RO | | | RO |

YOUT1/YOUT2 register contain the y-axis acceleration data and the new data flag for the y-axis.

### YOUT2 Register (05h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| YOUT[11:4] | | | | | | | |
| 8'b00000000 | | | | | | | |
| RO | | | | | | | |

### ZOUT1 Register (06h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| ZOUT[3:0] | | | | reserved | | | NEW_Z |
| 4'b0000 | | | | 3'b000 | | | 0 |
| RO | | | | RO | | | RO |

ZOUT1/ZOUT2 register contain the z-axis acceleration data and the new data flag for the z-axis.

### ZOUT2 Register (07h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| ZOUT[11:4] | | | | | | | |
| 8'b00000000 | | | | | | | |
| RO | | | | | | | |

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## INTSTS1 Register (09h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| reserved | | | | | ANY_MOT_STS | reserved | SIG_MOT_STS |
| 5'b00000 | | | | | 0 | 0 | 0 |
| RO | | | | | RO | RO | RO |

This register contains the interrupts status in STK8BA53.

| BIT | BIT NAME | Description |
|---|---|---|
| 0 | SIG_MOT_STS | Significant motion interrupt status. '1' : event triggered, '0' : no event. |
| 2 | ANY_MOT_STS | Any-motion (slope) detection interrupt status. '1' : event triggered, '0' : no event. |

## INTSTS2 Register (0Ah)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| DATA_STS | reserved | | | | | | |
| 0 | 7'b0000000 | | | | | | |
| RO | RO | | | | | | |

This register contains the new data interrupt status in STK8BA53.

| BIT | BIT NAME | Description |
|---|---|---|
| 7 | DATA_STS | New data interrupt status. '1' : event triggered, '0' : no event. |

## EVENTINFO1 Register (0Bh)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| reserved | SLPSIGN_Z | SLPSIGN_Y | SLPSIGN_X | reserved | SLP_1ST_Z | SLP_1ST_Y | SLP_1ST_X |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RO | RO | RO | RO | RO | RO | RO | RO |

This register contains any-motion (slope) detection information.

| BIT | BIT NAME | Description |
|---|---|---|
| 0 | SLP_1ST_X | 1 : Motion on the X-axis cause SLOPE interrupt asserted. |
| 1 | SLP_1ST_Y | 1 : Motion on the Y-axis cause SLOPE interrupt asserted. |
| 2 | SLP_1ST_Z | 1 : Motion on the Z-axis cause SLOPE interrupt asserted. |
| 4 | SLPSIGN_X | Sign of acceleration slope on the X-axis that triggered the SLOPE interrupt.<br>0 : positive. 1 : negative. |
| 5 | SLPSIGN_Y | Sign of acceleration slope on the Y-axis that triggered the SLOPE interrupt.<br>0 : positive. 1 : negative. |
| 6 | SLPSIGN_Z | Sign of acceleration slope on the Z-axis that triggered the SLOPE interrupt.<br>0 : positive. 1 : negative. |

## RANGESEL Register (0Fh)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| reserved | | | | RANGE[3:0] | | | |
| 4'b0000 | | | | 4'b0011 | | | |
| RO | | | | R/W | | | |

This register contains the acceleration sensing range.

| RANGE[3:0] | Sensing Range |
|---|---|
| 4'b0011 | ±2g |
| 4'b0101 | ±4g |
| 4'b1000 | ±8g |
| others | undefined |

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## BWSEL Register (10h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| reserved | | | BW[4:0] | | | | |
| 3'b000 | | | 5'b11111 | | | | |
| RO | | | R/W | | | | |

This register contains the output data bandwidth selection.

| BW[4:0] | Actual Bandwidth (Hz) |
|---|---|
| 5'b00xxx | 7.81 |
| 5'b01000 | 7.81 |
| 5'b01001 | 15.63 |
| 5'b01010 | 31.25 |
| 5'b01011 | 62.5 |
| 5'b01100 | 125 |
| 5'b01101 | 250 |
| 5'b01110 | 500 |
| 5'b01111 | 1000 |
| 5'b1xxxx | 1000 |

## POWMODE Register (11h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| SUSPEND | LOWPOWER | reserved | SLEEP_DUR[3:0] | | | | reserved |
| 0 | 0 | 0 | 4'b0000 | | | | 0 |
| R/W | R/W | RO | R/W | | | | RO |

This register contains the power mode selection and the sleep time duration setting.

| BIT | BIT NAME | Description |
|---|---|---|
| [4:1] | SLEEP_DUR[3:0] | Sleep time duration.<br>SLEEP_DUR[3:0] / Duration (ms)<br>4'b0000 ~ 4'b0101 / 0.5<br>4'b0110 / 1<br>4'b0111 / 2<br>4'b1000 / 4<br>4'b1001 / 6<br>4'b1010 / 10<br>4'b1011 / 25<br>4'b1100 / 50<br>4'b1101 / 100<br>4'b1110 / 500<br>4'b1111 / 1000 |
| 6 | LOWPOWER | 0 : low-power mode disable.<br>1 : low-power mode enable. |
| 7 | SUSPEND | 0 : suspend mode disable.<br>1 : suspend mode enable. |

## DATASETUP Register (13h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| DATA_SEL | PROTECT_DIS | reserved | | | | | |
| 0 | 0 | 6'b000000 | | | | | |
| R/W | R/W | RO | | | | | |

This register is used to select if the output data is filtered or unfiltered and how the output data contained in the register XOUT1/XOUT2, YOUT1/YOUT2, ZOUT1/ZOUT2 are updated.

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| BIT | BIT NAME | Description |
|---|---|---|
| 6 | PROTECT_DIS | 0 : Enable the data protection function.<br>1 : Disable the data protection function. |
| 7 | DATA_SEL | 0 : Data output filtered.<br>1 : Data output unfiltered. |

## SWRST Register (14h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| SWRST[7:0] | | | | | | | |
| 8'b00000000 | | | | | | | |
| W | | | | | | | |

This register is used to software reset. Write 0xB6 into SWRST to reset all the registers to default value.

## INTEN1 Register (16h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| reserved | | | | | SLP_EN_Z | SLP_EN_Y | SLP_EN_X |
| 5'b00000 | | | | | 0 | 0 | 0 |
| RO | | | | | R/W | R/W | R/W |

This register contains the several interrupt enable bit.

| BIT | BIT NAME | Description |
|---|---|---|
| 0 | SLP_EN_X | 0 : Disable X-axis any-motion (slope) interrupt.<br>1 : Enable X-axis any-motion (slope) interrupt. |
| 1 | SLP_EN_Y | 0 : Disable Y-axis any-motion (slope) interrupt.<br>1 : Enable Y-axis any-motion (slope) interrupt. |
| 2 | SLP_EN_Z | 0 : Disable Z-axis any-motion (slope) interrupt.<br>1 : Enable Z-axis any-motion (slope) interrupt. |

## INTEN2 Register (17h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| Reserved | | | DATA_EN | reserved | | | |
| 3'b000 | | | 0 | 4'b0000 | | | |
| RO | | | R/W | RO | | | |

This register contains the several interrupt enable bit.

| BIT | BIT NAME | Description |
|---|---|---|
| 4 | DATA_EN | 0 : Disable new data interrupt.<br>1 : Enable new data interrupt. |

## INTMAP1 Register (19h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| Reserved | | | | | ANYMOT2INT1 | reserved | SIGMOT2INT1 |
| 5'b00000 | | | | | 0 | 0 | 0 |
| RO | | | | | R/W | RO | R/W |

This register is used to map the related interrupt to the desired INT pin.

| BIT | BIT NAME | Description |
|---|---|---|
| 0 | SIGMOT2INT1 | 0 : Do not map significant motion interrupt to INT1.<br>1 : Map significant motion interrupt to INT1. |
| 2 | ANYMOT2INT1 | 0 : Do not map any-motion (slope) interrupt to INT1.<br>1 : Map any-motion (slope) interrupt to INT1. |

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## INTMAP2 Register (1Ah)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| reserved | | | | | | | DATA2INT1 |
| 7'b0000000 | | | | | | | 0 |
| RO | | | | | | | R/W |

This register is used to map the related interrupt to the desired INT pin.

| BIT | BIT NAME | Description |
|---|---|---|
| 0 | DATA2INT1 | 0 : Do not map new data interrupt to INT1.<br>1 : Map new data interrupt to INT1. |

## INTCFG1 Register (20h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| reserved | | | | | | INT1_OD | INT1_LV |
| 6'b000000 | | | | | | 0 | 1 |
| RO | | | | | | R/W | R/W |

This register is used to define the INT1 pin output type and active level. Open-drain or Push-pull output type and active high or active low can be selected.

| BIT | BIT NAME | Description |
|---|---|---|
| 0 | INT1_LV | INT1 active level selection.<br>0 : Active low.<br>1 : Active high. |
| 1 | INT1_OD | INT1 output type selection.<br>0 : Push-pull output type.<br>1 : Open-drain output type. |

## INTCFG2 Register (21h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| INT_RST | reserved | | | INT_LATCH[3:0] | | | |
| 0 | 3'b000 | | | 4'b0000 | | | |
| R/W | RO | | | R/W | | | |

This register is used to reset latched interrupt pin and select the interrupt mode.

| BIT | BIT NAME | Description |
|---|---|---|
| [3:0] | INT_LATCH[3:0] | INT pin output mode selection. |
| 7 | INT_RST | 1 : Reset any latched interrupt pin. |

| INT_LATCH[3:0] | Output Mode |
|---|---|
| 4'b0000 | non-latched |
| 4'b0001 | temporary, 250ms |
| 4'b0010 | temporary, 500ms |
| 4'b0011 | temporary, 1s |
| 4'b0100 | temporary, 2s |
| 4'b0101 | temporary, 4s |
| 4'b0110 | temporary, 8s |
| 4'b0111 | latched |
| 4'b1000 | non-latched |
| 4'b1001 | temporary, 250us |
| 4'b1010 | temporary, 500us |
| 4'b1011 | temporary, 1ms |
| 4'b1100 | temporary, 12.5ms |
| 4'b1101 | temporary, 25ms |
| 4'b1110 | temporary, 50ms |
| 4'b1111 | latched |

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## SLOPEDLY Register (27h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| reserved | | | | | | SLP_DUR[1:0] | |
| 6'b000000 | | | | | | 2'b00 | |
| RO | | | | | | R/W | |

This register is used to set the number of samples needed in slope detection. The actual number of samples will be equal to SLP_DUR[1:0] + 1.

## SLOPETHD Register (28h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| SLP_THD[7:0] | | | | | | | |
| 8'b00010100 | | | | | | | |
| R/W | | | | | | | |

This register is used to set the threshold value for the slope detection. The actual slope threshold will depend on sensing range. The default value of SLP_THD[7:0] is 0x14.

| RANGE[3:0] | Sensing Range | Actual Slope Threshold (mg) |
|---|---|---|
| 4'b0011 | ±2g | SLP_THD[7:0] * 3.91 |
| 4'b0101 | ±4g | SLP_THD[7:0] * 7.81 |
| 4'b1000 | ±8g | SLP_THD[7:0] * 15.63 |

## SIGMOT1 Register (29h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| SKIP_TIME[7:0] | | | | | | | |
| 8'b10010110 | | | | | | | |
| R/W | | | | | | | |

This register is used to set the skip time for the significant motion. Holding the duration for skip, for which the motion is checked for re-detection. 1 LSB=20 ms. Range is 0 to 10sec. The default value of SKIP_TIME[8:0] is 0x96 correspond to 3 seconds.

## SIGMOT2 Register (2Ah)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| reserved | | | | | ANY_MOT_EN | SIG_MOT_EN | SKIP_TIME[8] |
| 5'b00000 | | | | | 0 | 1 | 0 |
| RO | | | | | R/W | R/W | R/W |

This register contains MSB of SKIP_TIME[8:0] for the significant motion, and significant motion interrupt enable bit.

| BIT | BIT NAME | Description |
|---|---|---|
| 1 | SIG_MOT_EN | 0 : Disable significant motion.<br>1 : Enable significant motion. |
| 2 | ANY_MOT_EN | 0 : Disable any-motion.<br>1 : Enable any-motion. |

## SIGMOT3 Register (2Bh)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| reserved | PROOF_TIME[7:0] | | | | | | |
| 0 | 7'b0110010 | | | | | | |
| RO | R/W | | | | | | |

This register is used to set the proof time for the significant motion. Holding the duration for proof, for which the motion is re-checked after. 1 LSB=20 ms. Range is 0 to 2.5sec. The default value of PROOF_TIME[8:0] is 0x32 correspond to 1 seconds.

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## INTFCFG Register (34h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| reserved | | | | | I2C_WDT_EN | I2C_WDT_SEL | reserved |
| 5'b00000 | | | | | 0 | 0 | 0 |
| RO | | | | | R/W | R/W | RO |

This register contains the digital interface parameters for the I²C interface.

| BIT | BIT NAME | Description |
|---|---|---|
| 1 | I2C_WDT_SEL | I²C watchdog timer period selection.<br>0 : Watchdog timer period 1ms.<br>1 : Watchdog timer period 50ms. |
| 2 | I2C_WDT_EN | I²C watchdog timer enable bit.<br>0 : Disable I2C watchdog timer.<br>1 : Enable I2C watchdog timer. |

## OFSTCOMP1 Register (36h)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| OFST_RST | reserved | | | | | | |
| 0 | 2'b0000000 | | | | | | |
| W | R | | | | | | |

This register is used to define the setting for the offset compensation.

| BIT | BIT NAME | Description |
|---|---|---|
| 7 | OFST_RST | 1 : Reset all the offset compensation register (register 0x38 ~ 0x3A) to zero. |

## OFSTX Register (38h)

| B7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| OFST_X[7:0] | | | | | | | |
| 8'b00000000 | | | | | | | |
| R/W | | | | | | | |

This register contains the offset compensation value for the x-axis data output.

## OFSTY Register (39h)

| B7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| OFST_Y[7:0] | | | | | | | |
| 8'b00000000 | | | | | | | |
| R/W | | | | | | | |

This register contains the offset compensation value for the y-axis data output.

## OFSTZ Register (3Ah)

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|
| OFST_Z[7:0] | | | | | | | |
| 8'b00000000 | | | | | | | |
| R/W | | | | | | | |

This register contains the offset compensation value for the z-axis data output.

Register 0x38 to 0x3A can be modified manually set by user. The value in these register will be added to the actual acceleration data sensing by STK8BA58 and store the new value to XOUT/YOUT/ZOUT register.

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# 10. APPLICATION INFORMATION

## 10.1 New Data Interrupt

This interrupt serves for synchronous reading of acceleration data. It is generated after storing a new value of z-axis acceleration data in the data register. The interrupt is cleared automatically when the next cycle of data acquisition starts. The interrupt status is '0' for at least 50μs. The interrupt mode of the new data interrupt is fixed to non-latched for at least 250 us.

| Control Register | Bit Name | Function |
|---|---|---|
| INTEN2[4] | DATA_EN | '1': enabled, '0': disabled, and the interrupt mode is fixed to non-latched. |
| INTSTS[7] | DATA_STS | The interrupt status. |
| INTMAP2 | DATA2INT1 | New data interrupt maps to INT1. |
| DATASETUP[5] | DATA_SEL | '1': unfiltered data, '0': filtered data, as the input of the new data interrupt. |

## 10.2 Any-motion (Slope) Detection

Any-motion (slope) detection is to detect the change of motion. By monitoring the slop of acceleration, user can estimate the variation of acceleration. STK8BA58 use the slop between successive acceleration data to detect it, and would active the interrupt when the slop exceeds a preset threshold. Moreover, a duration setting has to be configured to suppress failure signals. The following figure shows the relationship between acceleration data, acceleration slop, and INT status. If a certain number *N* of consecutive slope data points is larger (smaller) than the slope threshold, the INT would be trigger (clear).

One LSB of SLP_THD [7:0] represents 1 LSB of acceleration data, and it depends on which sensing range is set. For Example, 3.91mg in 2g-range, 7.81 mg in 4g-range, 15.6 mg in 8g-range and 31.3 mg in 16g-range. The consecutive slope data points are set by SLP_DUR [1:0], and is equal to (SLP_DUR [1:0] + 1). The time difference between the successive acceleration signals depends on the selected bandwidth and equates to 1/(2*bandwidth).

Any-motion (slope) detection can be enabled by writing '1' to ANY_MOT_EN bit in the register SIGMOT2 (0x2A). Furthermore, user must select which axes are enabled independently by writing '1' to the bit SLP_EN_X, SLP_EN_Y, and SLP_EN_Z in the register INTEN1 (0x16).

If slope of any axis fulfills the specified condition, INT pin would be triggered, interrupt status would be updated to ANY_MOT_STS, and the sign of slop would be shown in SLPSIGN_X, SLPSIGN_Y, SLPSIGN_Z. Moreover, SLP_1ST_X, SLP_1ST_Y, and SLP_1ST_Z would indicate which axis is the first axis triggering the interrupt of slop detection.

| Control Register | Bit Name | Function |
|---|---|---|
| INTEN1 [0]<br>INTEN1 [1]<br>INTEN1 [2] | SLP_EN_X<br>SLP_EN_Y<br>SLP_EN_Z | Slope detection enable for X-axis, '1': enabled, '0': disabled<br>for Y-axis, '1': enabled, '0': disabled<br>for Z-axis, '1': enabled, '0': disabled |
| SIGMOT2[2] | ANY_MOT_EN | Any-motion enable bit. 0: Disabled. 1: Enabled. |
| SLOPETHD [7:0] | SLP_THD | Slope threshold, 1LSB=1LSB of XOUT/YOUT/ZOUT |
| SLOPEDLY [1:0] | SLP_DUR | Slope duration, 1LSB=1/(2*bandwidth) |
| INTMAP1 | ANTMOT2INT1 | Slope detection interrupt maps to INT1 |
| INTSTS1 [2] | ANT_MOT _STS | Slope detection status which is synchronized with INT1 activity |
| DATASETUP [7] | DATA_SEL | '1': unfiltered data, '0': filtered data, as the input of the slop detection |
| EVENTINFO1 [0]<br>EVENTINFO1 [1]<br>EVENTINFO1 [2] | SLP_1ST_X<br>SLP_1ST_Y<br>SLP_1ST_Z | '1': triggered axis, '0': not triggered |
| EVENTINFO1 [4]<br>EVENTINFO1 [5]<br>EVENTINFO1 [6] | SLPSIGN_X<br>SLPSIGN_Y<br>SLPSIGN_Z | Sign of slope when interrupt is triggered, '0': Positive, '1': Negative |

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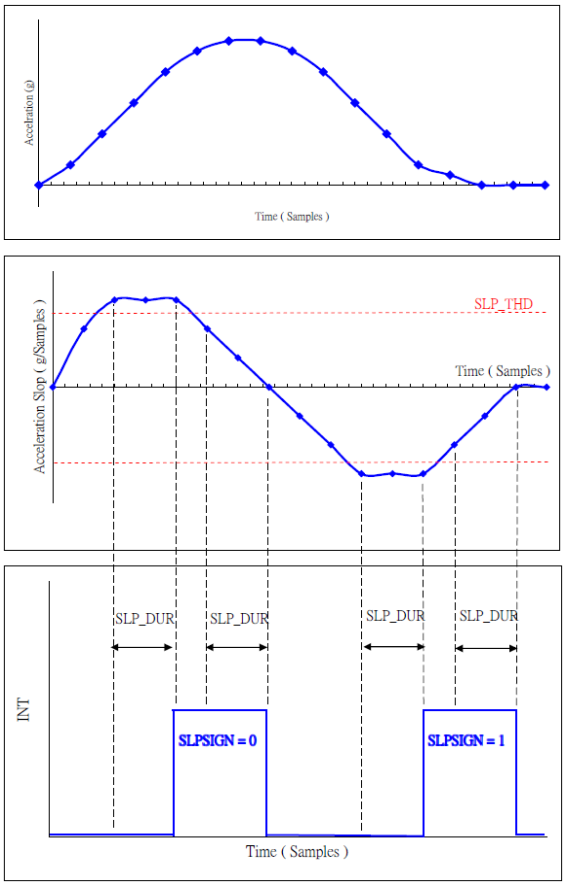


*Note1: In order to ensure motion algorithm working normally, interrupt latched mode must be set before motion algorithms enabled.*

*Note2: It's not recommended that motion algorithm working in the low-power mode and set BW less than 1k Hz simultaneously.*

## 10.3 Significant Motion

The significant motion is defined as some activities that might lead to a change in a user's location. Examples of significant motions are walking or biking, sitting in a moving car, coach or train, etc. Examples of situations that should not trigger significant motion include phone in pocket and person is not moving, phone is on a table and the table shakes a bit due to nearby traffic or washing machine. For more information, please refer to Android Sensor types: https://source.android.com/devices/sensors/sensor-types.html#significant_motion.

Significant motion function would be triggered by means of monitoring the slope of acceleration over a period of time. The algorithm will be started when a motion is detected, and generates a signal if another motion is detected after the SKIP_TIME[8:0] (0x29-0x2A) and within the PROOF_TIME[7:0] (0x2B). Both 1 LSB of skip time and proof time correspond to 20ms.

The significant motion and slope detection share event-triggered settings including independent XYZ-axes slope enable bit INTEN1 [2:0] (0x16), threshold SLOPETHD [7:0] (0x28), duration SLOPEDLY [1:0] (0x27). User should be noticed that the slope detection has to be enabled before enabling significant motion due to a sharing algorithm engine. Then enable significant motion by writing '1' to SIG_MOT_EN bit in register SIGMOT2 (0x2A).

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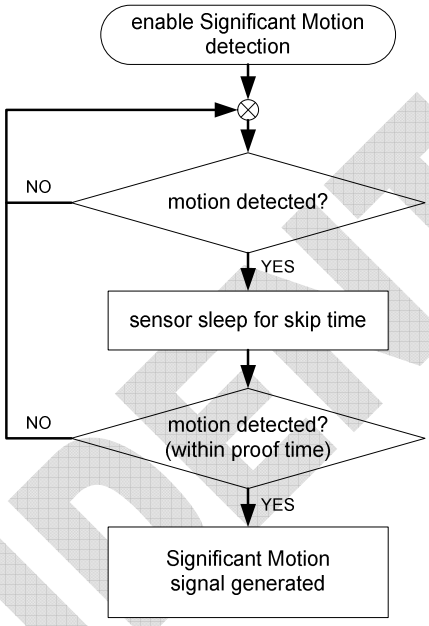
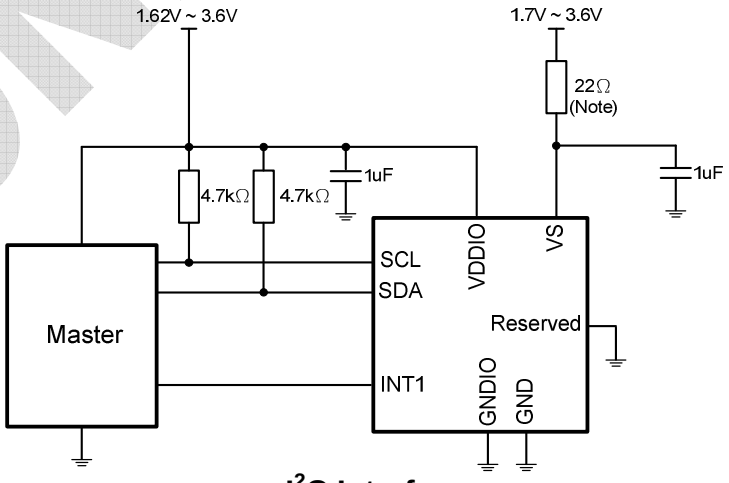
Follow the steps below to enable significant motion:

**Step1.** (MUST) Set interrupt configurations INTCFG1 (0x20) and INTCFG2 (0x21).
**Step2.** Set configuration settings include SKIP_TIME[8:0] (0x29-0x2A), PROOF_TIME[7:0] (0x2B), SLOPEDLY[1:0] (0x27) and SLOPETHD[7:0] (0x28).
**Step3.** Set XYZ-axes slope detection enabled by INTEN1[2:0] (0x16).
**Step4.** Set significant motion enabled by SIGMOT2[1] (0x2A).
**Step5.** Mapping significant motion to physical interrupt pin by INTMAP1[0] (0x19).
**Step6.** Wait for INT triggered or monitor SIG_MOT_STS bit in INTSTS1[0] (0x09)




**Significant Motion algorithm flow chart**

## 10.4 Application Circuit




**I²C Interface**

Note: A 22 ohm resistor is recommended to filter out the system power noise.

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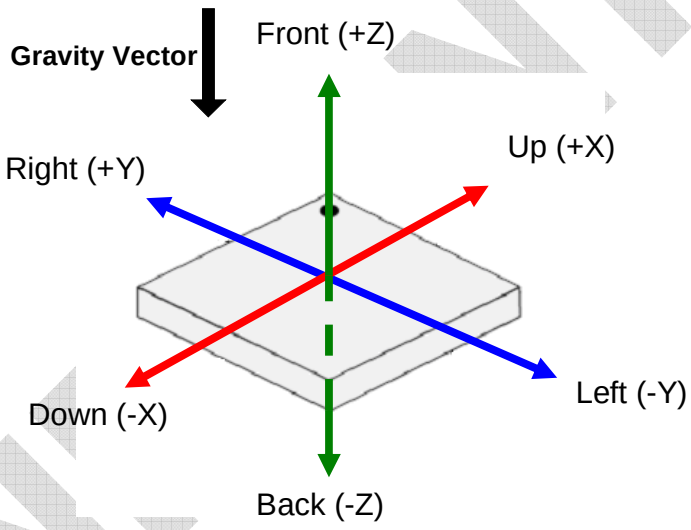
## 10.5 Sensing Axes Orientation

By measuring the acceleration components respect to g field, the position and orientation information could be recognized. It could be used for such applications as Portrait/Landscape in Mobile phone/PDA/PMP. This enables a product to set its display orientation appropriately to either portrait/landscape mode, or to turn off the display if the product is placed upside down. The sensor provides positive or negative directions of X/Y/Z axes. The relationship between directions and six different positions: Left, Right, Up, Down, Back, and Front, is shown in the following figure.

If the sensor is at rest and the force of gravity is acting along the indicated directions, the output of the corresponding channel will be negative (static acceleration).

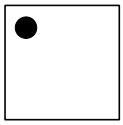
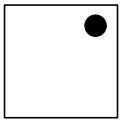
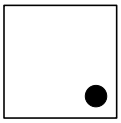
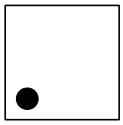
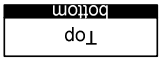
Example: If the sensor is at rest or at uniform motion in a gravity field according to the figure given below, the output signals are:

± 0g for the X-axis
± 0g for the Y-axis
+ 1g for the Z-axis




**Sensing axes orientation**

The following table lists all corresponding output signals on X, Y, and Z while the sensor is at rest or at uniform motion in a gravity field under assumption of a ±2g range setting, a 12 bit resolution, and a top down gravity vector as shown above.

| Sensor Orientation & Gravity Vector |  Top View |  Top View |  Top View |  Top View |   Side View |   Side View |
|---|---|---|---|---|---|---|
| X-axis Output | +1g/1024LSB | 0g / 0 LSB | -1g/1024LSB | 0g / 0 LSB | 0g / 0 LSB | 0g / 0 LSB |
| Y-axis Output | 0g / 0 LSB | +1g/1024LSB | 0g / 0 LSB | -1g/1024LSB | 0g / 0 LSB | 0g / 0 LSB |
| Z-axis Output | 0g / 0 LSB | 0g / 0 LSB | 0g / 0 LSB | 0g / 0 LSB | +1g/1024LSB | -1g/1024LSB |

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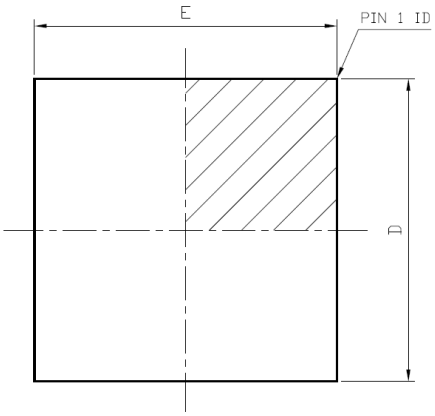
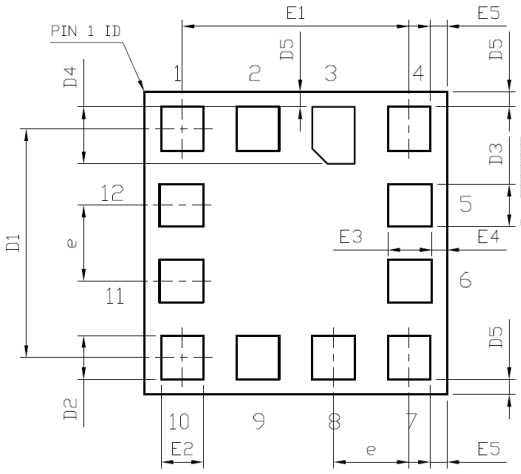
# 11. PACKAGE OUTLINE

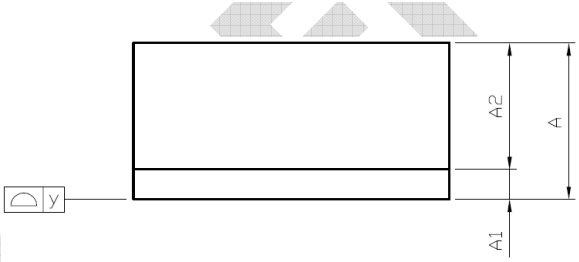
## 11.1 Package Outline Drawing




TOP VIEW




BOTTOM VIEW




SIDE VIEW

| SYMBOLS | DIMENSIONS IN MILLIMETERS | | |
|---|---|---|---|
| | MIN. | NOM. | MAX |
| A | 0.95 | 1.00 | 1.05 |
| A1 | 0.16 | 0.19 | 0.22 |
| A2 | | 0.80 REF. | |
| D | 1.95 | 2.00 | 2.05 |
| D1 | | 1.51 REF. | |
| D2 | 0.24 | 0.29 | 0.34 |
| D3 | 0.23 | 0.28 | 0.33 |
| D4 | 0.325 | 0.375 | 0.425 |
| D5 | | 0.10 REF. | |
| E | 1.95 | 2.00 | 2.05 |
| E1 | | 1.50 REF. | |
| E2 | 0.23 | 0.28 | 0.33 |
| E3 | 0.24 | 0.29 | 0.34 |
| E4 | | 0.10 REF. | |
| E5 | | 0.11 REF. | |
| e | | 0.50 REF. | |
| y | 0.00 | --- | 0.10 |

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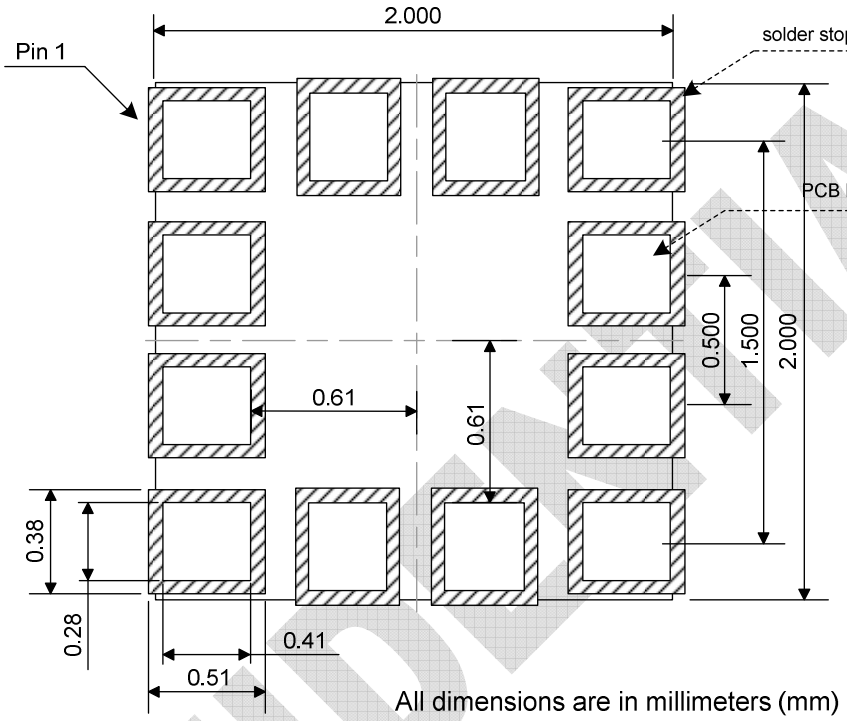
## 11.2 Recommended PCB Layout

The PCB layout should use NSMD (Non Solder mask Defined) pad definitions for all pads. The solder mask opening must be defined at least 0.05 mm larger than the metal pad on all sides.




## 11.3 Marking Rule

| Marking | Symbol | Name |
|---|---|---|
| YYYY<br>XXXX<br>● | YYYY | Order number |
| | XXXX | Product serial number |
| | ● | Pin1 dot |

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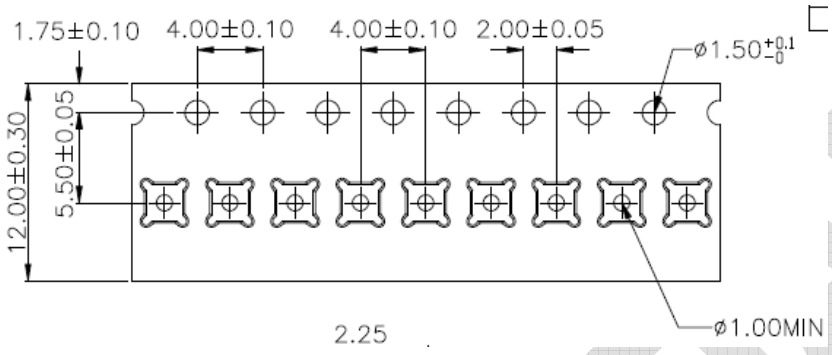
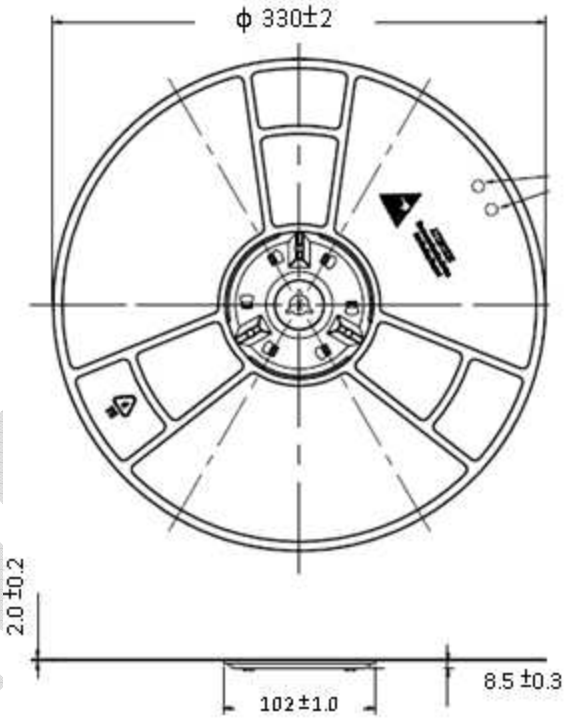
## 11.4 Tape and Reel Information

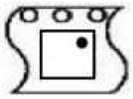
1. Carrier Tape Specification




2. Reel Specification




3. Unit Orientation

| | |
|---|---|
| Process direction |  |
| Orientation in carrier |  |
| Orientation by quadrant |   |

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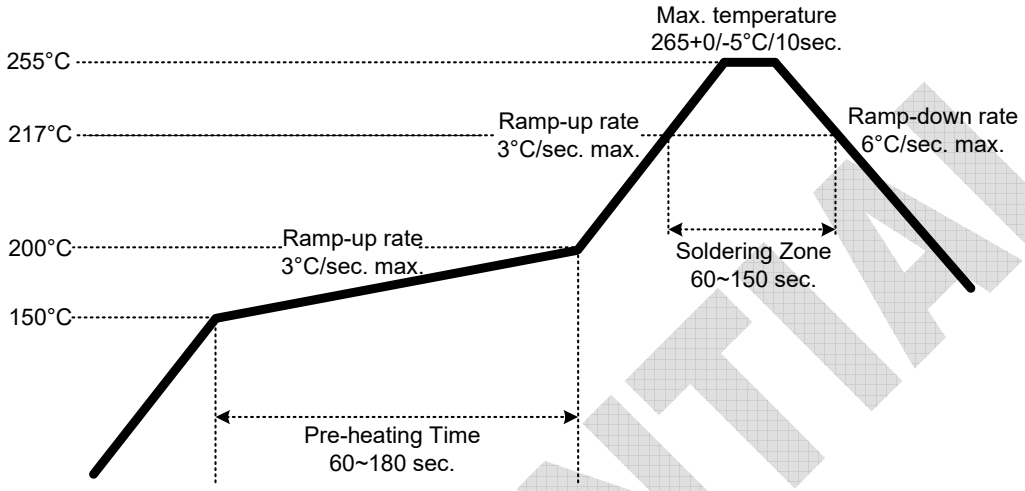
## 11.5 Soldering Condition

1. Pb-free solder temperature profile



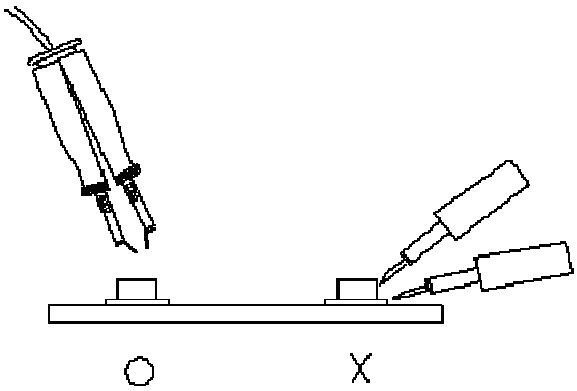

2. Reflow soldering should not be done more than three times.
3. When soldering, do not put stress on the ICs during heating.
4. After soldering, do not warp the circuit board.

## 11.6 Soldering Iron

Each terminal is to go to the tip of soldering iron temperature less than 350℃ for 3 seconds within once in less than the soldering iron capacity 25W. Leave two seconds and more intervals, and do soldering of each terminal. Be careful because the damage of the product is often started at the time of the hand solder.

## 11.7 Repairing

Repair should not be done after the ICs have been soldered. When repairing is unavoidable, a double-head soldering iron should be used (as below figure). It should be confirmed beforehand whether the characteristics of the ICs will or will not be damaged by repairing.

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# 12. STORAGE INFORMATION

## 12.1 Storage Condition

1. Devices are packed in moisture barrier bags (MBB) to prevent the products from moisture absorption during transportation and storage. Each bag contains a desiccant.
2. The delivery product should be stored with the conditions shown below:

| | |
|---|---|
| Storage Temperature | 10 to 30℃ |
| Relatively Humidity | below 60%RH |

## 12.2 Treatment After Unsealed

1. Floor life (time between soldering and removing from MBB) must not exceed the time shown below:

| | |
|---|---|
| Floor Life | 168 Hours |
| Storage Temperature | 10 to 30℃ |
| Relatively Humidity | below 60%RH |

2. When the floor life limits have been exceeded or the devices are not stored in dry conditions, they must be re-baked before reflow to prevent damage to the devices. The recommended conditions are shown below

| | |
|---|---|
| Temperature | 60℃ |
| Re-Baking Time | 12 Hours |

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## Revision History

| Date | Version | Modified Items |
|---|---|---|
| 2019/11/26 | 1.0 | Initial release. |
| | | |

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