STK8313

Digital Output 3-axis MEMS Accelerometer

Preliminary Datasheet

Version - 0.9.7
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Sensortek Technology Corporation

1. OVERVIEW

Description

The STK8313 is a ±2g/±4g/±8g/±16g, 3-axis linear accelerometer, with I^2C digital output. It is a very low power, low profile capacitive MEMS sensor featuring, compensation for 0g offset and gain errors, and conversion to 12-bit digital values at a user configurable samples per second. The self-test capability allows the user to check the functioning of the sensor in the final application. The device can be arranged for sensor data changes, orientation, tap/double tap, and free fall functions through two interrupt pins. The STK8313 is available in a small 3mm x 3mm x 0.85mm QFN package and it is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

Feature

- Low Voltage Operation:
  – Analog Voltage: 2.4 V – 3.6 V
  – Digital Voltage: 1.7 V – 3.6 V
- ±2g/±4g±/8g/±16g dynamically selectable full-scale
- I^2C digital output interface and 2 interrupt
- 12 bit data output
- Embedded self-test
- 10000 g high shock survivability
- 3mm x 3mm x 0.85mm QFN Package
- Configurable Samples per Second from 3.125 to 400 samples a second.
- Auto-Wake/Sleep Feature for Low Power Consumption
- Tilt Orientation Detection for Portrait/Landscape Capability
- Shake Detection
- Tap and double Tap Detection
- Free Fall Detection
- RoHS Compliant
- Halogen Free
- Environmentally Preferred Product

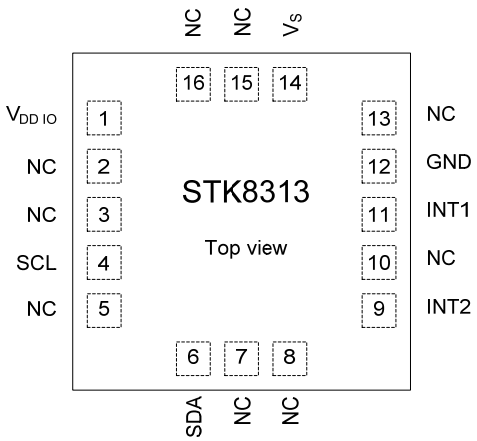
Applications

- Free-fall detection
- Intelligent power saving for handheld devices
- Pedometer
- Display orientation
- Gaming and virtual reality input devices
- Impact recognition and logging
- Vibration monitoring and compensation

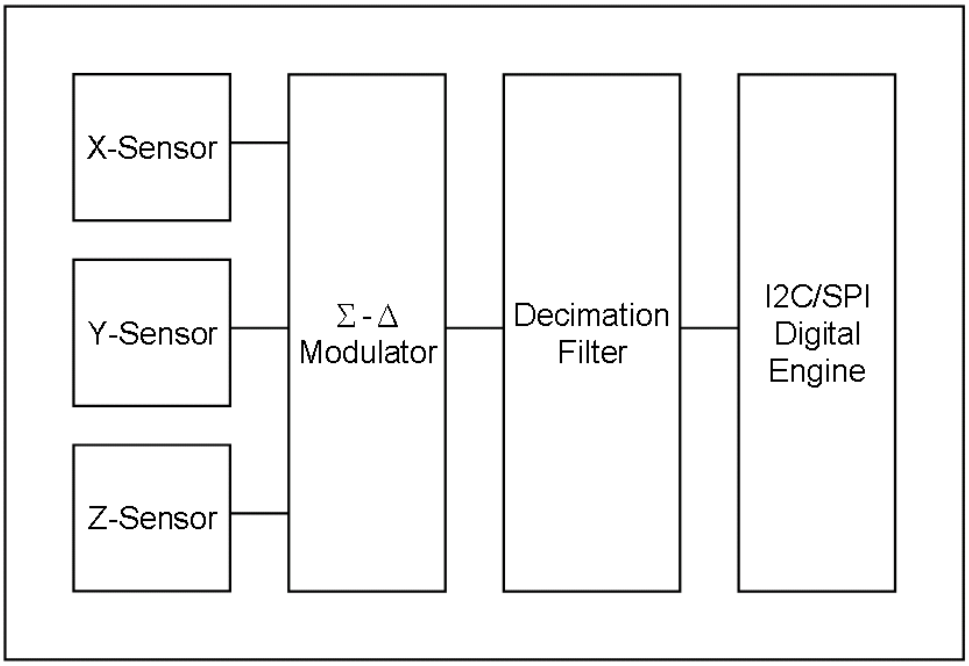
2. PIN DESCRIPTION

Pin#	Name	Function
1	$V_{DD\ I/O}$	Digital Interface Supply Voltage.
2	NC	Not Internally Connected.
3	NC*	Not Internally Connected.
4	SCL	Serial Communications Clock.
5	NC*	Not Internally Connected.
6	SDA	Serial Data (I^2C)
7	NC	Not Internally Connected.
8	NC	Not Internally Connected.
9	INT2	Interrupt 2 Output.
10	NC*	Not Internally Connected.
11	INT1	Interrupt 1 Output.
12	GND	Must be connected to ground.
13	NC	Not Internally Connected.
14	V_S	Supply Voltage.
15	NC	Not Internally Connected.
16	NC	Not Internally Connected.

*Pin3, Pin5, Pin10 are not connected to internal circuit, but are shorted together.



3. FUNCTION BLOCK



4. ELECTRICAL SPECIFICATIONS

T_A = 25°C, V_S = 2.8 V, $V_{DD\ I/O}$ = 2.8 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 (V_S)		2.4	2.8	3.6	V
Interface Voltage Range ($V_{DD\ I/O}$)		1.7		3.6	V
Current consumption in active mode			149		µA
Current consumption in auto-wakeup mode[1]	ODR = 25Hz		122		µA
	ODR = 3.125Hz		57		
Current consumption in standby mode				1	µA
Digital high level input voltage (VIH)		0.7 x $V_{DD\ I/O}$			V
Digital low level input voltage (VIL)				0.3 x $V_{DD\ I/O}$	V
High level output voltage (VOH)[1]		0.8 x $V_{DD\ I/O}$			V
Low level output voltage (VOL)[1]				0.2 x $V_{DD\ I/O}$	V
OUTPUT DATA RATE AND BANDWIDTH	Each axis				
Output data rate (ODR)	in active mode	3.125		400	Hz
	in auto-wakeup mode	3.125		25	Hz
Bandwidth (BW)			ODR/2		Hz

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

5. MECHANICAL SPECIFICATIONS

T_A = 25°C, V_S = 2.8 V, $V_{DD\ I/O}$ = 2.8 V, acceleration = 0 *g*, C_S = $C_{I/O}$ = 10 µF and 0.1 µF

Parameter	Test Conditions	Min	Typ	Max	Unit
SENSOR INPUT	Each axis				
Measurement Range	User selectable		±2, ±4, ±8, ±16		g
Nonlinearity	Percentage of full scale		±0.28		%
Cross-Axis Sensitivity			TBD		Degree
OUTPUT RESOLUTION	Each axis				
±2 g Range	Full resolution		10		Bits
±4 g Range	Full resolution		11		Bits
±8 g Range	Full resolution		12		Bits
±16 g Range	Full resolution		12		Bits
SENSITIVITY	Each axis				
Sensitivity at XOUT, YOUT, ZOUT	±2g, 10-bit resolution	230	256	282	LSB/g
	±4g, 11-bit resolution	230	256	282	LSB/g
	±8g, 12-bit resolution	230	256	282	LSB/g
	±16g, 12-bit resolution	115	128	141	LSB/g
Sensitivity Change Due to Temperature	X-, Y-Axes		0.004		%/°C
	Z-Axis		0.01		%/°C
0 g OFFSET[1]	Each axis				
0 g Output for XOUT, YOUT, ZOUT			±50		mg
0 g Offset vs. Temperature	X-Axis		0.7		mg/°C
	Y-Axis		0.3		mg/°C
	Z-Axis		1.9		mg/°C
NOISE					
X-, Y-Axes	±8g, 12-bit resolution		0.9		LSB rms
	ODR = 100Hz		500		µg/sqrt(Hz)
Z-Axis			1.0		LSB rms
			550		µg/sqrt(Hz)
X-, Y-Axes	±16g, 12-bit resolution		0.9		LSB rms
	ODR = 100Hz		1000		µg/sqrt(Hz)
Z-Axis			1.0		LSB rms
			1100		µg/sqrt(Hz)
SELF-TEST					
Output Change in X-Axis			TBD		g
Output Change in Y-Axis			TBD		g
Output Change in Z-Axis			TBD		g

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.

6. ABSOLUTE MAXIMUM RATINGS

Symbol	Ratings	Maximum value	Unit
V_S	Supply voltage	-0.3 to 3.6	V
$V_{DD\ I/O}$	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	4 (HBM)	kV
		500 (CDM)	V
		200 (MM)	V
		100 (Latch Up)	mA

7. DIGITAL INTERFACE

All registers in STK8313 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 line used for sending and receiving the data to/from the interface. Both the lines are connected to DVDD through a pull-up external resistor.

To reset the STK8313 without having to reset the entire I^2C bus, an explicit reset command is provided. If register 0x20 is set to 0x00, STK8313 will reset all register and enter into standby mode. To reset STK8313 after power on is recommended.

In following timing chart, it is STK8313 I^2C command format description for reading and writing operation between the host and STK8313.

Slave Address

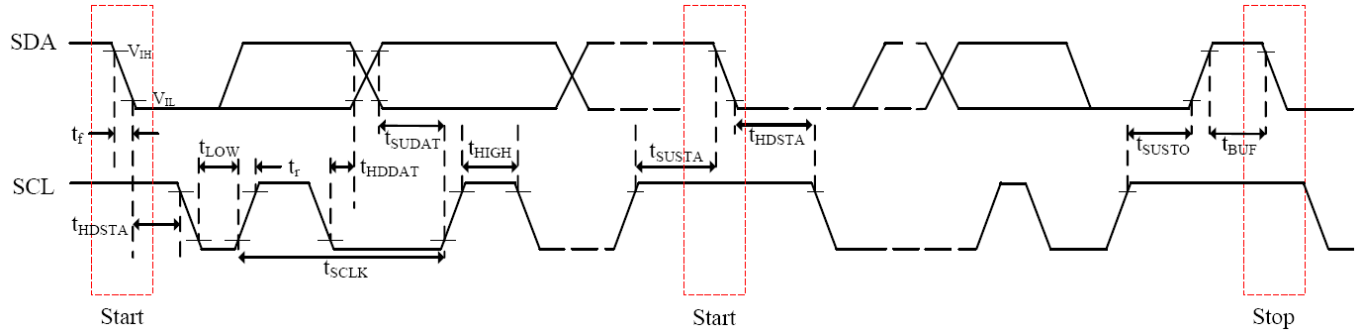
STK8312 provides the fixed slave address of 0x22 using 7-bit addressing protocol. In following table, it describes the command setting.

Device Address	R/W Command Bit	OPERATION
0x22 (followed by the R/ W bit)	0	Write Data to STK8313
	1	Read Data form STK8313

Characteristics of the I2C Timing

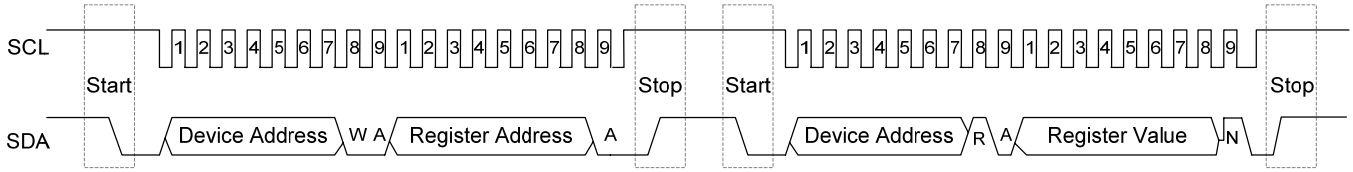
Symbol	Parameter	Standard Mode		Fast Mode		Unit
		Min.	Max.	Min.	Max.	
f_{SCLK}	SCL clock frequency	10	100	10	400	KHz
t_{HDSTA}	Hold time after (repeated) start condition. After this period, the first clock is generated	4.0	—	0.6	—	μs
t_{LOW}	LOW period of the SCL clock	4.7	—	1.3	—	μs
t_{HIGH}	HIGH period 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	—	120	—	120	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 1: f_{SCLK} is the $(t_{SCLK})^{-1}$.

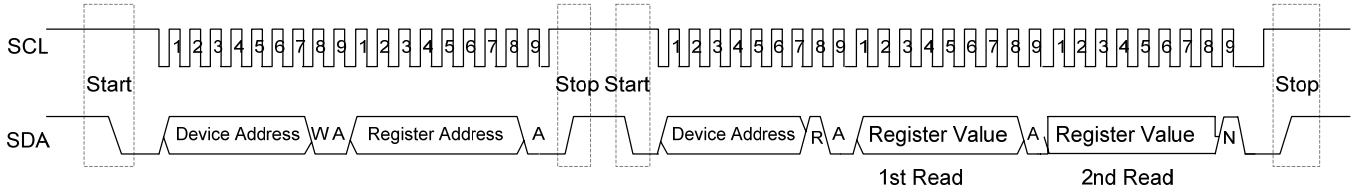


Timing Chart of the I2C

Write Command



Read Data



Sequential Read Data

8. FEATURES

8.1 Mode of Operation

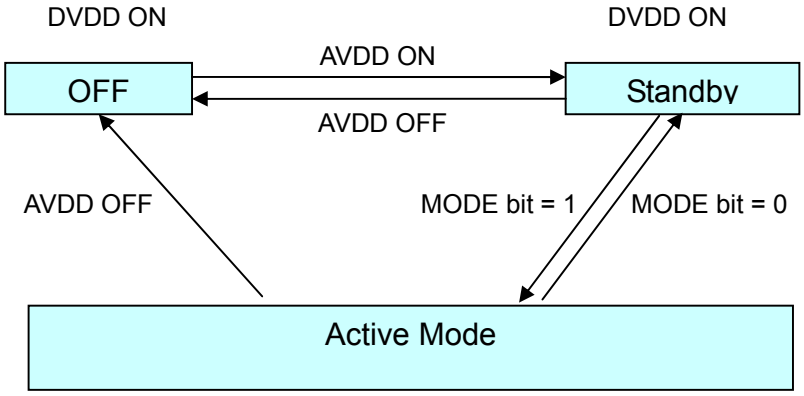
The sensor has three power modes: Off Mode, Standby Mode, and Active Mode to offer the customer different power consumption options. Only one mode could be acceptable at a time.

The Off Mode offers the lowest power consumption and can only be reached by powering down the analog supply. In this mode, there is no analog supply but digital supply. Therefore some basic register could be accessed by I2C, but no data appear at XOUT, YOUT, ZOUT register.

The Standby Mode is ideal for battery operated products. When Standby Mode is active the device outputs are turned off providing a significant reduction in operating current. When the device is in Standby Mode the current will be reduced to less than 1 μA. Standby Mode is entered as soon as both analog and digital power supplies are up. In this mode, the device can read and write to the registers with I2C, but no new measurements can be taken. The mode of the device is controlled through the MODE (0x0A) control register by accessing the mode bit in the Mode register.

During the Active Mode, continuous measurement on all three axes is enabled. In addition, the user can choose to enable: Shake Detection, Tap Detection, Double-Tap Detection, Orientation Detection, Free-Fall Detection, and/or Auto-Wake/Sleep Feature and in this mode the digital analysis for any of these functions is done. The user can configure the samples per second to any of the following: 3.125 samples/second, 6.25 samples/second, 12.5 samples/second, 25 samples/second, 50 samples/second, 100 samples/second, 200 samples/second, and 400 samples/second, for the Auto-Sleep state. If the user is configuring the Auto-Wake feature, the selectable ranges are: 3.125 sample/second, 6.25 samples/second, 12.5 samples/second, 25 samples/second. Depending on the samples per second selected the power consumption will vary.

Measurement Mode	I²C Bus	DVDD	AVDD	Function
Off Mode	STK8313 will respond to I2C bus	ON	OFF	Only I2C available, but no data output. Functions could not be normally set at this mode.
Standby Mode	STK8313 will respond to I2C bus	ON	ON	STK8313 is powered up in both supplies, so registers can be accessed normally to set STK8313 to Active Mode when desired. STK8313's sensor measurement system is idle.
Active Mode	STK8313 will respond to I2C bus	ON	ON	STK8313 is able to operate sensor measurement system at user programmable samples per second and run all of the digital analysis functions. Tap detection operates in Active Mode.



8.2 Status and Interrupt Event Detection

The Sensor employs both analog and digital filtering to ensure low noise and accurate output when using the part for Shake, Double-Tap, Tap, Free-Fall, or Orientation Detection. During Active Mode, the data is filtered and stored for each of the 3 axes at the specified following measurement intervals: 3.125 sample/second, 6.25 sample/second, 12.5 sample/second, 25 sample/second, 50 sample/second, 100 sample/second, 200 sample/second, 400 sample/second or indicated in AMSR [2:0].

The measurement data is stored in the XOUT1 (0x00), XOUT2 (0x01), YOUT1 (0x02), YOUT2 (0x03), and ZOUT1 (0x04), ZOUT2 (0x05) registers and is used to update the Statue: Shake, Alert, Tap, PoLa[2:0] (updates Up, Down, Left, and Right position), BaFro[1:0] (updates Back and Front position) in the TILT (0x06) register, and FFAL, DTap in the SRST (0x07) register.

The Shake status always responds to any measurement data over shake threshold value (STH[2:0] in the STH (0x16) register), and the PoLa[2:0] and BaFro[1:0] status respond to orientation. However, the Tap and DTap status will respond only when ZDA, YDA, or XDA in PDET (0x0C) register are enabled. The FFAL Status and Interrupt are controlled by FFINT in ISTMP (0x17). If FFINT is enabled, the FFAL status and interrupt will simultaneously occur.

The customer can configure the part by enabling a number of user desired interrupts in the INTSU (0x09) and ISTMP(0x17) register. Once the interrupts are enabled a change in filtered readings will cause an interrupt to occur depending on the output.

Interrupt Event Summary

Interrupt Event	Settings
Orientation	When FBINT, PLINT = 1
Shake	When SHINTX, SHINTY, SHINTZ = 1
Tap	When PDINT = 1
Double Tap	When DPINT = 1
X, Y, Z Data Update	When GINT = 1
Free Fall	When FFINT = 1
Auto-Wake/Sleep	When ASINT = 1

Status Summary

Status	Settings
PoLa[2:0], BaFro[1:0]	Always available
Shake	Always available
Tap, DTap	When enable ZDA, YDA, or XDA
FFAL	When FFINT = 1

NOTE: Sensor Measurements are NOT taken in Standby Mode or in Test Mode.

9. REGISTER DEFINATION

Address	Name	Definition	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
$00	XOUT1	12 bit output X MSBs	XOUT[11]	XOUT[10]	XOUT[9]	XOUT[8]	XOUT[7]	XOUT[6]	XOUT[5]	XOUT[4]
$01	XOUT2	12 bit output X LSBs	XOUT[3]	XOUT[2]	XOUT[1]	XOUT[0]	-	-	-	-
$02	YOUT1	12 bit output Y MSBs	YOUT[11]	YOUT[10]	YOUT[9]	YOUT[8]	YOUT[7]	YOUT[6]	YOUT[5]	YOUT[4]
$03	YOUT2	12 bit output Y LSBs	YOUT[3]	YOUT[2]	YOUT[1]	YOUT[0]	-	-	-	-
$04	ZOUT1	12 bit output Z MSBs	ZOUT[11]	ZOUT[10]	ZOUT[9]	ZOUT[8]	ZOUT[7]	ZOUT[6]	ZOUT[5]	ZOUT[4]
$05	ZOUT2	12 bit output Z LSBs	ZOUT[3]	ZOUT[2]	ZOUT[1]	ZOUT[0]	-	-	-	-
$06	TILT	Tilt Status	Shake	Alert	Tap	PoLa[2]	PoLa[1]	PoLa[0]	BaFro[1]	BaFro[0]
$07	SRST	Sampling Rate Status	0	0	0	0	FFAL	DTap	Reserved	AMSRS
$08										
$09	INTSU	Interrupt Setup	SHINTX	SHINTY	SHINTZ	GINT	Reserved	PDINT	PLINT	FBINT
$0A	MODE	Mode	IAH	IPP	Reserved	Reserved	Reserved	TON	Reserved	MODE
$0B	SR	Auto-Wake/Sleep and Portrait/Landscape samples per seconds and Debounce Filter	FILT[2]	FILT[1]	FILT[0]	AWSR[1]	AWSR[0]	AMSR[2]	AMSR[1]	AMSR[0]
$0C	PDET	Tap Detection	ZDA	YDA	XDA	PDTH[4]	PDTH[3]	PDTH[2]	PDTH[1]	PDTH[0]
$0D	-	Reserved	-	-	-	-	-	-	-	-
$0E										
$0F	OFSX	X-Axis offset	OFSX[7]	OFSX[6]	OFSX[5]	OFSX[4]	OFSX[3]	OFSX[2]	OFSX[1]	OFSX[0]
$10	OFSY	Y-Axis offset	OFSY[7]	OFSY[6]	OFSY[5]	OFSY[4]	OFSY[3]	OFSY[2]	OFSY[1]	OFSY[0]
$11	OFSZ	Z-Axis offset	OFSZ[7]	OFSZ[6]	OFSZ[5]	OFSZ[4]	OFSZ[3]	OFSZ[2]	OFSZ[1]	OFSZ[0]
$12	PLAT	Tap Latency	PLAT[7]	PLAT[6]	PLAT[5]	PLAT[4]	PLAT[3]	PLAT[2]	PLAT[1]	PLAT[0]
$13	PWIN	Tap Window	PWIN[7]	PWIN[6]	PWIN[5]	PWIN[4]	PWIN[3]	PWIN[2]	PWIN[1]	PWIN[0]
$14	FTH	Free-Fall Threshold	FTH[7]	FTH[6]	FTH[5]	FTH[4]	FTH[3]	FTH[2]	FTH[1]	FTH[0]
$15	FTM	Free-Fall Time	FTM[7]	FTM[6]	FTM[5]	FTM[4]	FTM[3]	FTM[2]	FTM[1]	FTM[0]
$16	STH	Dynamic Range Setup and Shake Threshold	RNG[1]	RNG[0]	-	-	-	STH[2]	STH[1]	STH[0]
$17	ISTMP	Interrupt Setup and Map	MFFINT	MDPINT	-	-	AOI	-	FFINT	DPINT
$18	INTMAP	Interrupt Map	MSHINTX	MSHINTY	MSHINTZ	MGINT	MASINT	MPDINT	MPLINT	MFBINT
$20	SWRST	Software Rest	SWRST[7]	SWRST[6]	SWRST[5]	SWRST[4]	SWRST[3]	SWRST[2]	SWRST[1]	SWRST[0]

NOTE: To write to the registers the MODE bit in the MODE (0x0A) register must be set to 0, placing the device in Standby Mode.

$00: 12-bits MSBs output value X (Read Only when not in Test Mode)

XOUT1 — X MSBs Output

D7	D6	D5	D4	D3	D2	D1	D0
XOUT[11]	XOUT[10]	XOUT[9]	XOUT[8]	XOUT[7]	XOUT[6]	XOUT[5]	XOUT[4]
0	0	0	0	0	0	0	0

This is the MSBs of X-axis output which is signed byte 12-bit 2's complement data with allowable range of +2047 to -2048.
XOUT[11] is 0 if the g direction is positive, 1 if the g direction is negative.

$01: 12-bits LSBs output value X (Read Only when not in Test Mode)

XOUT2 — X LSBs Output

D7	D6	D5	D4	D3	D2	D1	D0
XOUT[3]	XOUT[2]	XOUT[1]	XOUT[0]	-	-	-	-
0	0	0	0	0	0	0	0

This is the LSBs of X-axis output which is signed byte 12-bit 2's complement data with allowable range of +2047 to -2048.

$02: 12-bits MSBs output value Y (Read Only when not in Test Mode)

YOUT1 — Y MSBs Output

D7	D6	D5	D4	D3	D2	D1	D0
YOUT[11]	YOUT[10]	YOUT[9]	YOUT[8]	YOUT[7]	YOUT[6]	YOUT[5]	YOUT[4]
0	0	0	0	0	0	0	0

This is the MSBs of Y-axis output which is signed byte 12-bit 2's complement data with allowable range of +2047 to -2048.
YOUT[11] is 0 if the g direction is positive, 1 if the g direction is negative.

$03: 12-bits LSBs output value Y (Read Only when not in Test Mode)
YOUT2 — Y LSBs Output

D7	D6	D5	D4	D3	D2	D1	D0
YOUT[3]	YOUT[2]	YOUT[1]	YOUT[0]	-	-	-	-
0	0	0	0	0	0	0	0

This is the LSBs of Y-axis output which is signed byte 12-bit 2's complement data with allowable range of +2047 to -2048.

$04: 12-bits MSBs output value Z (Read Only when not in Test Mode)
ZOUT1 — Z MSBs Output

D7	D6	D5	D4	D3	D2	D1	D0
ZOUT[11]	ZOUT[10]	ZOUT[9]	ZOUT[8]	ZOUT[7]	ZOUT[6]	ZOUT[5]	ZOUT[4]
0	0	0	0	0	0	0	0

This is the MSBs of Z-axis output which is signed byte 12-bit 2's complement data with allowable range of +2047 to -2048.
ZOUT[11] is 0 if the g direction is positive, 1 if the g direction is negative.

$05: 12-bits LSBs output value Z (Read Only when not in Test Mode)
ZOUT2 — Z LSBs Output

D7	D6	D5	D4	D3	D2	D1	D0
ZOUT[3]	ZOUT[2]	ZOUT[1]	ZOUT[0]	-	-	-	-
0	0	0	0	0	0	0	0

This is the LSBs of Z-axis output which is signed byte 12-bit 2's complement data with allowable range of +2047 to -2048.

$06: Tilt Status (Read only)
TILT

D7	D6	D5	D4	D3	D2	D1	D0
Shake	Alert	Tap	Pola[2]	Pola[1]	Pola[0]	BaFro[1]	BaFro[0]
0	0	0	0	0	0	0	0

Shake
0: Equipment is not experiencing shake in one or more of the axes enabled by SHINTX, SHINTY, and SHINTZ
1: Equipment is experiencing shake in one or more of the axes enabled by SHINTX, SHINTY, and SHINTZ

Alert
0: Register data is valid
1: If the Alert bit is set, the register was read at the same time as the device was attempting to update the contents. The register must be read again.

Tap
1: Equipment has detected a tap
0: Equipment has not detected a tap

PoLa[2:0]
000: Unknown condition of up or down or left or right
001: Left: Equipment is in landscape mode to the left
010: Right: Equipment is in landscape mode to the right
101: Down: Equipment standing vertically in inverted orientation
110: Up: Equipment standing vertically in normal orientation

BaFro[1:0]
00:Unknown condition of front or back
01: Front: Equipment is lying on its front
10: Back: Equipment is lying on its back

Note: When entering active mode from standby mode, if the device is flat (±1g on Z-axis) the value for BaFro will be back (-1g) or front (+1g) but PoLa will be in unknown condition. if the device is being held in an Up/Down/Right/Left position, the PoLa value will be updated with current orientation, but BaFro will be in unknown condition.

$07: Sample Rate Status Register (Read only)
SRST

D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	FFAL	DTap	Reserved	AMSRS
0	0	0	0	0	0	0	0

FFAL
1: Equipment has detected free fall
0: Equipment has not detected free fall

DTap
1: Equipment has detected double tap
0: Equipment has not detected double tap

AMSRS
0: Samples per second specified in AMSR[2:0] is not active
1: Samples per second specified in AMSR[2:0] is active

$09: Interrupt Setup Register (Read/Write)
INTSU

D7	D6	D5	D4	D3	D2	D1	D0
SHINTX	SHINTY	SHINTZ	GINT	Reserved	PDINT	PLINT	FBINT
0	0	0	0	0	0	0	0

SHINTX
0: Shake on the X-axis does not cause an interrupt or set the Shake bit in the TILT register
1: Shake detected on the X-axis causes an interrupt, and sets the Shake bit in the TILT register

SHINTY
0: Shake on the Y-axis does not cause an interrupt or set the Shake bit in the TILT register
1: Shake detected on the Y-axis causes an interrupt, and sets the Shake bit in the TILT register

SHINTZ
0: Shake on the Z-axis does not cause an interrupt or set the Shake bit in the TILT register
1: Shake detected on the Z-axis causes an interrupt, and sets the Shake bit in the TILT register.

GINT
0: There is not an automatic interrupt after every measurement
1: There is an automatic interrupt after every measurement, when g-cell readings are updated in XOUT, YOUT, ZOUT registers, regardless of whether the readings have changed or not.

PDINT
0: Successful tap detection does not cause an interrupt
1: Successful tap detection causes an interrupt

PLINT
0: Up/Down/Right/Left position change does not cause an interrupt
1: Up/Down/Right/Left position change causes an interrupt

FBINT
0: Front/Back position change does not cause an interrupt
1: Front/Back position change causes an interrupt

The active interrupt condition (IRQ = 0 if IAH = 0, IRQ = 1 if IAH = 1) is released during the acknowledge bit of the slave address transmission of the first subsequent I^2C to STK8312 after the interrupt was asserted.

$0A: Mode Register (Read/Write)
MODE

D7	D6	D5	D4	D3	D2	D1	D0
IAH	IPP	Reserved	Reserved	Reserved	Reserved	Reserved	MODE
0	0	0	0	0	0	0	0

NOTE: The device must be placed in Standby Mode to change the value of the registers.

Table 1. Modes

Mode of Operation	D0 - MODE
Standby Mode	0
Active Mode	1

IAH
0: Interrupt output INT is active low
1: Interrupt output INT is active high

IPP
0: Interrupt output INT is open-drain.
1: Interrupt output INT is push-pull
NOTE: Do NOT connect pull-up resistor from INT to higher voltage than DVDD.

TON
0: Standby Mode or Active Mode depending on state of MODE
1: Test Mode Existing state of MODE bit must be 0, to write TON = 1. Device must be in Standby Mode. In Test Mode (TON = 1), the data in the XOUT, YOUT and ZOUT registers is *not* updated by measurement, but is instead updated by the user through the I2C interface for test purposes. Changes to the XOUT, YOUT and ZOUT register data is processed by STK8312-000 to change orientation status and generate interrupts just like Active Mode. Debounce filtering, free-fall, and shake detection are disabled in Test Mode.

MODE
0: Standby mode
1: Active mode. STK8312 always enters Active Mode using the samples per second specified in AMSR[2:0] of the SR (0x08) register.

The active interrupt condition (IRQ = 0 if IAH = 0, IRQ = 1 if IAH = 1) is released during the acknowledge bit of the slave address transmission of the first subsequent I^2C to STK8312 after the interrupt was asserted.

$0B: Auto-Wake and Active Mode Portrait/Landscape Samples per Seconds Register (Read/Write)
SR — Sample Rate Register

D7	D6	D5	D4	D3	D2	D1	D0
FILT[2]	FILT[1]	FILT[0]	Reserved	Reserved	AMSR[2]	AMSR[1]	AMSR[0]
0	0	0	0	0	0	0	0

AMSR[2:0]	NAME	DESCRIPTION
000	AMPD	**400** Samples/Second Active and Auto-Sleep Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active and Auto-Sleep Mode. Tap detection: itself compares the two consecutive axis responses described above for each axis. The absolute (unsigned) difference between those axis responses is compared against the tap detection delta threshold value PDTH[4:0] in the PDET (0x09) register. **Free-fall Detection:** The update rate is **400** samples per second. **For portrait/landscape and shake detection:**. The update rate is **400** samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also.
001	AM64	**200** Samples/Second Active and Auto-Sleep Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active and Auto-Sleep Mode. Tap detection: itself compares the two consecutive axis responses described above for each axis. The absolute (unsigned) difference between those axis responses is compared against the tap detection delta threshold value PDTH[4:0] in the PDET (0x09) register. **Free-fall Detection:** The update rate is **200** samples per second. **For portrait/landscape and shake detection**: The update rate is **200** samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also.
010	AM32	**100** Samples/Second Active and Auto-Sleep Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active and Auto-Sleep Mode. Tap detection: itself compares the two consecutive axis responses described above for each axis. The absolute (unsigned) difference between those axis responses is compared against the tap detection delta threshold value PDTH[4:0] in the PDET (0x09) register. **Free-fall Detection:** Function is disabled. **For portrait/landscape and shake detection:** The update rate is **100** samples per second. These measurements update XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also.

011	AM16	**50** Samples/Second Active and Auto-Sleep Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active and Auto-Sleep Mode. Tap detection: itself compares the two consecutive axis responses described above for each axis. The absolute (unsigned) difference between those axis responses is compared against the tap detection delta threshold value PDTH[4:0] in the PDET (0x09) register. **Free-fall Detection:** Function is disabled. **For portrait/landscape and shake detection:** The update rate is **50** samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also.
100	AM8	**25** Samples/Second Active and Auto-Sleep Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active and Auto-Sleep Mode. Tap detection: itself compares the two consecutive axis responses described above for each axis. The absolute (unsigned) difference between those axis responses is compared against the tap detection delta threshold value PDTH[4:0] in the PDET (0x09) register. **Free-fall Detection:** Function is disabled. **For portrait/landscape and shake detection:** The update rate is **25** samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also.
101	AM4	**12.5** Samples/Second Active and Auto-Sleep Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active and Auto-Sleep Mode. Tap detection: itself compares the two consecutive axis responses described above for each axis. The absolute (unsigned) difference between those axis responses is compared against the tap detection delta threshold value PDTH[4:0] in the PDET (0x09) register. **Free-fall Detection:** Function is disabled. **For portrait/landscape and shake detection:** The update rate is **12.5** samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also.
110	AM2	**6.25** Samples/Second Active and Auto-Sleep Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active and Auto-Sleep Mode. Tap detection: itself compares the two consecutive axis responses described above for each axis. The absolute (unsigned) difference between those axis responses is compared against the tap detection delta threshold value PDTH[4:0] in the PDET (0x09) register. **Free-fall Detection:** Function is disabled. **For portrait/landscape and shake detection:** The update rate is **6.25** samples per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also.
111	AM1	**3.125** Sample/Second Active and Auto-Sleep Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active and Auto-Sleep Mode. Tap detection: itself compares the two consecutive axis responses described above for each axis. The absolute (unsigned) difference between those axis responses is compared against the tap detection delta threshold value PDTH[4:0] in the PDET (0x09) register. **Free-fall Detection:** Function is disabled. **For portrait/landscape and shake detection:** The update rate is **3.125** sample per second. These measurements update the XOUT (0x00), YOUT (0x01), and ZOUT (0x02) registers also.

FILT[2:0]	DESCRIPTION
000	Tilt debounce filtering is disabled. The device updates portrait/landscape every reading at the rate set by AMSR[2:0] or AWSR[1:0]
001	2 measurement samples at the rate set by AMSR[2:0] or AWSR[1:0] have to match before the device updates portrait/ landscape data in TILT (0x06) register.
010	3 measurement samples at the rate set by AMSR[2:0] or AWSR[1:0] have to match before the device updates portrait/ landscape data in TILT (0x06) register.
011	4 measurement samples at the rate set by AMSR[2:0] or AWSR[1:0] have to match before the device updates portrait/ landscape data in TILT (0x06) register.
100	5 measurement samples at the rate set by AMSR[2:0] or AWSR[1:0] have to match before the device updates portrait/ landscape data in TILT (0x06) register.
101	6 measurement samples at the rate set by AMSR[2:0] or AWSR[1:0] have to match before the device updates portrait/ landscape data in TILT (0x06) register.
110	7 measurement samples at the rate set by AMSR[2:0] or AWSR[1:0] have to match before the device updates portrait/ landscape data in TILT (0x06) register.
111	8 measurement samples at the rate set by AMSR[2:0] or AWSR[1:0] have to match before the device updates portrait/ landscape data in TILT (0x06) register.

$0C: Tap/Pulse Detection Register (Read/Write)

PDET

D7	D6	D5	D4	D3	D2	D1	D0
ZDA	YDA	XDA	PDTH[4]	PDTH[3]	PDTH[2]	PDTH[1]	PDTH[0]
0	0	0	0	0	0	0	0

NOTE: If XDA = YDA = ZDA = 0, and Auto-Sleep feature is enabled, the tap interrupt will reset the sleep counter.

ZDA
1: Z-axis is disabled for tap detection
0: Z-axis is enabled for tap detection

YDA
1: Y-axis is disabled for tap detection
0: Y-axis is enabled for tap detection

XDA
1: X-axis is disabled for tap detection
0: X-axis is enabled for tap detection

PDTH[4:0]	DESCRIPTION
00000	Tap detection threshold is ±62.5 mg
00001	
00010	Tap detection threshold is ±125 mg
00011	Tap detection threshold is ±187.5 mg
…	... and so on up to...
11101	Tap detection threshold is ±1812.5 mg
11110	Tap detection threshold is ±1875 mg
11111	Tap detection threshold is ±1937.5 mg

$0F: X-Axis Offset Register (Read/Write)
OFSX

D7	D6	D5	D4	D3	D2	D1	D0
OFSX[7]	OFSX[6]	OFSX[5]	OFSX[4]	OFSX[3]	OFSX[2]	OFSX[1]	OFSX[0]
0	0	0	0	0	0	0	0

The OFSX register is eight bits and offers user-set adjustments in twos complement format with a scale factor of 3.9mg/LSB at ±2g/±4g±/8g mode or 7.8mg/LSB at ±16g mode for x axis. The values stored in the offset register are automatically added to the acceleration data, and the resulting value is stored in the output data registers.

$10: Y-Axis Offset Register (Read/Write)
OFSY

D7	D6	D5	D4	D3	D2	D1	D0
OFSY[7]	OFSY[6]	OFSY[5]	OFSY[4]	OFSY[3]	OFSY[2]	OFSY[1]	OFSY[0]
0	0	0	0	0	0	0	0

The OFSY register is eight bits and offers user-set adjustments in twos complement format with a scale factor of 3.9mg/LSB at ±2g/±4g±/8g mode or 7.8mg/LSB at ±16g mode for y axis. The values stored in the offset register are automatically added to the acceleration data, and the resulting value is stored in the output data registers.

$11: Z-Axis Offset Register (Read/Write)
OFSZ

D7	D6	D5	D4	D3	D2	D1	D0
OFSZ[7]	OFSZ[6]	OFSZ[5]	OFSZ[4]	OFSZ[3]	OFSZ[2]	OFSZ[1]	OFSZ[0]
0	0	0	0	0	0	0	0

The OFSZ register is eight bits and offers user-set adjustments in twos complement format with a scale factor of 3.9mg/LSB at ±2g/±4g±/8g mode or 7.8mg/LSB at ±16g mode for z axis. The values stored in the offset register are automatically added to the acceleration data, and the resulting value is stored in the output data registers.

$12: Tap Latency Register (Read/Write)
PLAT

D7	D6	D5	D4	D3	D2	D1	D0
PLAT[7]	PLAT[6]	PLAT[5]	PLAT[4]	PLAT[3]	PLAT[2]	PLAT[1]	PLAT[0]
0	0	1	1	1	1	0	0

The latent register is eight bits and contains an unsigned time value representing the wait time from the detection of a tap event to

the start of the time window (defined by the window register) during which a possible second tap event can be detected. The scale factor is 5 ms/LSB. A value of 0 disables the double-tap function. The default value is 0x3C which is equivalent to 300 ms.

$13: Tap Window Register (Read/Write)

PWIN

D7	D6	D5	D4	D3	D2	D1	D0
PWIN[7]	PWIN[6]	PWIN[5]	PWIN[4]	PWIN[3]	PWIN[2]	PWIN[1]	PWIN[0]
0	0	1	1	1	1	0	0

The window register is eight bits and contains an unsigned time value representing the amount of time after the expiration of the latency time (determined by the PLAT register) during which a second valid tap can begin. The scale factor is 5 ms/LSB. A value of 0 disables the double-tap function. The default value is 0x3C which is equivalent to 300 ms.

$14: Free-Fall Threshold Register (Read/Write)

FTH

D7	D6	D5	D4	D3	D2	D1	D0
FTH[7]	FTH[6]	FTH[5]	FTH[4]	FTH[3]	FTH[2]	FTH[1]	FTH[0]
0	0	0	0	0	1	1	0

The FTH register is eight bits and holds the threshold value, in unsigned format, for free-fall detection. The acceleration on all axes is compared with the value in FTH to determine if a free-fall event occurred. The scale factor is 62.5 m*g*/LSB. Note that a value of 0 m*g* may result in undesirable behavior if the free-fall interrupt is enabled. Values between 375 m*g* and 750 m*g* (0x06 to 0x0C) are recommended. The default value is 0x06 which is equivalent to 375 mg.

$15: Free-Fall Time Register (Read/Write)

FTM

D7	D6	D5	D4	D3	D2	D1	D0
FTM[7]	FTM[6]	FTM[5]	FTM[4]	FTM[3]	FTM[2]	FTM[1]	FTM[0]
0	0	1	0	1	0	0	0

The FTM register is eight bits and stores an unsigned time value representing the minimum time that the value of all axes must be less than FTH to generate a free-fall interrupt. The scale factor is 5 ms/LSB. A value of 0 may result in undesirable behavior if the free-fall interrupt is enabled. Values between 100 ms and 350 ms (0x14 to 0x46) are recommended. The default value is 0x28 which is equivalent to 200 ms.

$16: Dynamic Range Setup and Shake Threshold Register (Read/Write)

STH

D7	D6	D5	D4	D3	D2	D1	D0
RNG[1]	RNG[0]	-	-	-	STH[2]	STH[1]	STH[0]
0	0	0	0	0	0	1	0

RNG

The RNG register is two bits which is used to select measurement range, and the following table lists the measurement range. When the **RNG[1:0] is selected, the resolution of output data automatically switch to the corresponding setting. User should note that the effective LSB bit under different resolution is aligned to XOUT[0], ZOUT[0], YOUT[0]**

RNG[1:0]	MEASUREMENT RANGE	Resolution
00	±2 g	10
01	±4 g	11
10	±8 g	12
11	±16 g	12

STH

The STH register is three bits and holds the threshold value, in unsigned format, for shake detection. The acceleration on all axes is compared with the value in STH to determine if a shake event occurred. The default value is 0x02 which is equivalent to 1.375 g shake threshold value. The following table lists the shake threshold value.

STH[2:0]	SHAKE THRESHOLD VALUE
000	1.125 g
001	1.250 g
010	1.375 g
011	1.500 g

100	1.625 g
101	1.750 g
110	1.875 g
111	2.000 g

$17: Interrupt Setup and Map Register (Read/Write)
ISTMP

D7	D6	D5	D4	D3	D2	D1	D0
MFFINT	MDPINT	-	-	AOI	-	FFINT	DPINT
0	0	0	0	0	0	0	0

MFFINT
0: Send free-fall interrupt to INT1 pin
1: Send free-fall interrupt to INT2 pin

MDPINT
0: Send double-tap interrupt to INT1 pin
1: Send double-tap interrupt to INT2 pin

AOI
0: OR combination of interrupt events
1: AND combination of interrupt events

FFINT
0: Successful free-fall detection does not cause an interrupt
1: Successful free-fall detection causes an interrupt

DPINT
0: Successful double-tap detection does not cause an interrupt
1: Successful double-tap detection causes an interrupt

$18: Interrupt Map Register (Read/Write)
INTMAP

D7	D6	D5	D4	D3	D2	D1	D0
MSHINTX	MSHINTY	MSHINTZ	MGINT	MASINT	MPDINT	MPLINT	MFBINT
0	0	0	0	0	0	0	0

Bits set to 0 in this register send their respective interrupts to the INT1 pin, whereas bits set to 1 send their respective interrupts to the INT2 pin. All selected interrupts for a given pin may be AND'ed or OR'ed, which depend on the status AOI bit of ISTMP register. It should be noted that Mxxxxx bit corresponds to xxxxx bit in INTSU register which used to send the interrupt to INT1 or INT2 pin.

$20: Software Reset Register (Write)
SWRST

D7	D6	D5	D4	D3	D2	D1	D0
SWRST[7]	SWRST[6]	SWRST[5]	SWRST[4]	SWRST[3]	SWRST[2]	SWRST[1]	SWRST[0]
0	0	0	0	0	0	0	0

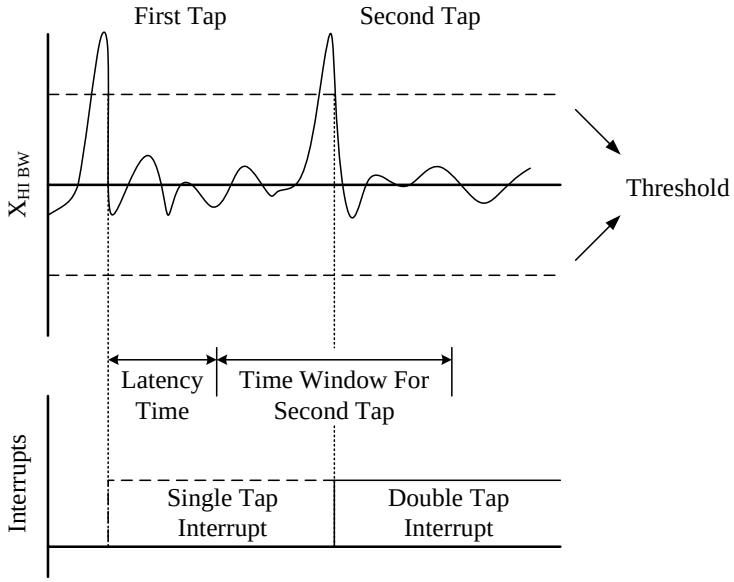
Set this register to 0x00 will reset STK8313 to standby mode, and all register will recover to default value. It's recommended that this register should be set to 0x00 after power on.

10. APPLICATION INFORMATION

TAP DETECTION

The tap interrupt function is capable of detecting either single or double taps. The following parameters are shown in the following Figure for a valid single-tap event and a valid double-tap event:

- The tap detection threshold is defined by the PDTH register (Address 0x0C).
- The tap latency time is defined by the latent register (Address 0x12) and is the waiting period from the end of the first tap until the start of the time window when a second tap can be detected, which is determined by the value in the window register (Address 0x13).
- The interval after the latency time (set by the latent register) is defined by the window register. Although a second tap must begin after the latency time has expired, it need not finish before the end of the time defined by the window register.



If only the single-tap function is in use, the single-tap interrupt is triggered when the acceleration goes below the threshold, as long as DUR has not been exceeded. If both single and double-tap functions are in use, the single-tap interrupt is triggered when the double-tap event has been either validated or invalidated.

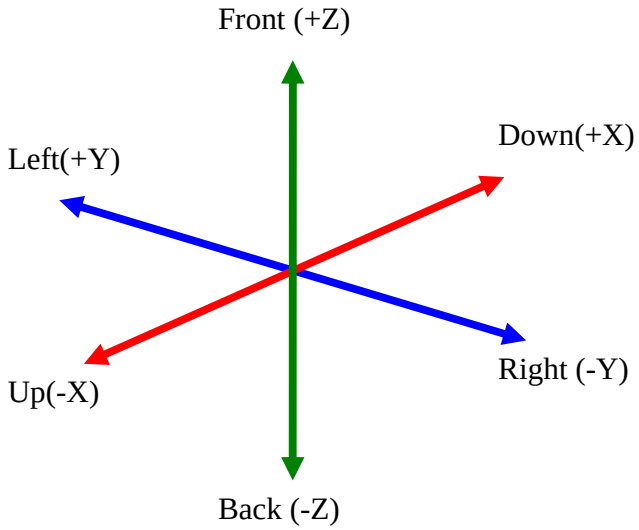
ORIENTATION DETECTION

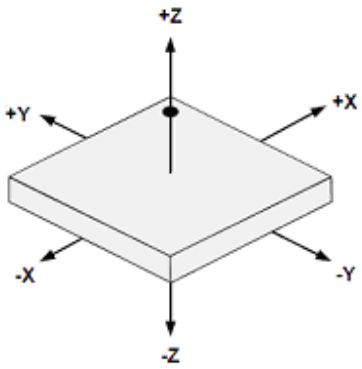
STK8313 gives the customer the capability to do orientation detection for such applications as Portrait/Landscape in Mobile phone/PDA/ PMP. The tilt orientation of the device is in 3 dimensions and is identified in its last known static position. This enables a product to set its display orientation appropriately to either portrait/landscape mode, or to turn off the display if the product is placed upside down. The sensor provides six different positions including: Left, Right, Up, Down, Back, and Front, shown in following table. In Active Mode the data is processed and updates the orientation positions in the TILT (0x06) register. At each measurement interval, it computes new values for Left, Right, Up, Down, Back, and Front but it does not automatically update these bits in the TILT (0x06) register. These values are updated depending on the debounce filter settings (SR Register 0x0B) configured by the customer.

In order to give the customer the ability to configure the debounce filter, specific to there application, they can change the following bits in the SR (0x0B) register, FILT [2:0]. Please see below for a more detailed explanation of how the FILT [2:0] works in conjunction with updating the TILT (0x06) register:

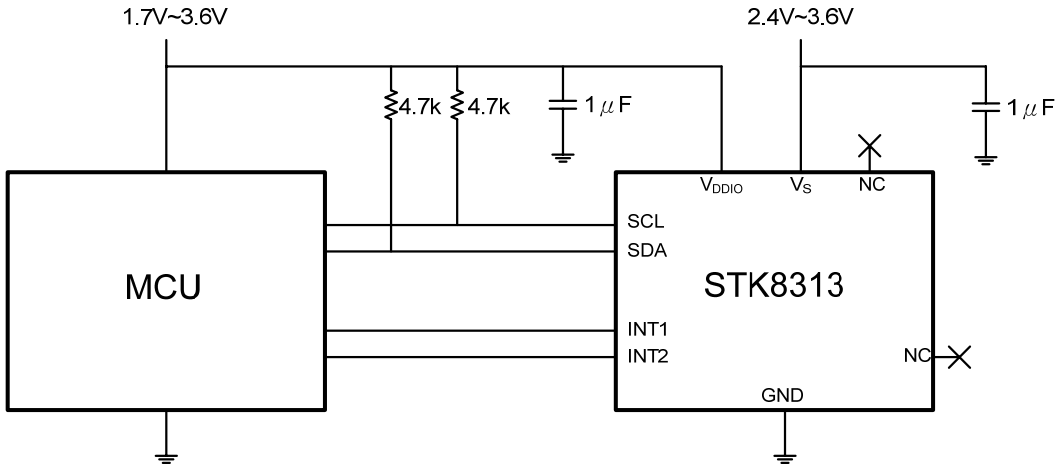
- If FILT [2:0] = 000, then the new values for Left, Right, Up, Down, Back, and Front are updated in the TILT (0x06) register (PoLa [2:0] and BaFro [1:0]) after every reading without any further analysis.
- If FILT [2:0] = 001 – 111, then the sensor requires the computed values for Left, Right, Up, Down, Back, and Front to be the same from 1-7 consecutive readings (depending on the value in FILT [2:0], before updating the values stored in TILT (0x06) register (PoLa [2:0] and BaFro [1:0]). The debounce counter is reset after a mismatched reading or the TILT (0x06) register is updated (if the orientation condition is met).

Orientation	Xg	Yg	Zg
Shake	|X| > STH or	|Y| > STH or	|Z| > STH
Up	|Z| < 0.8g and |X| > |Y| and X < 0		
Down	|Z| < 0.8g and |X| > |Y| and X > 0		
Right		|Z| < 0.8g and |Y| > |X| and Y < 0	
Left		|Z| < 0.8g and |Y| > |X| and Y > 0	
Back			Z < -0.25g
Front			Z > 0.25g

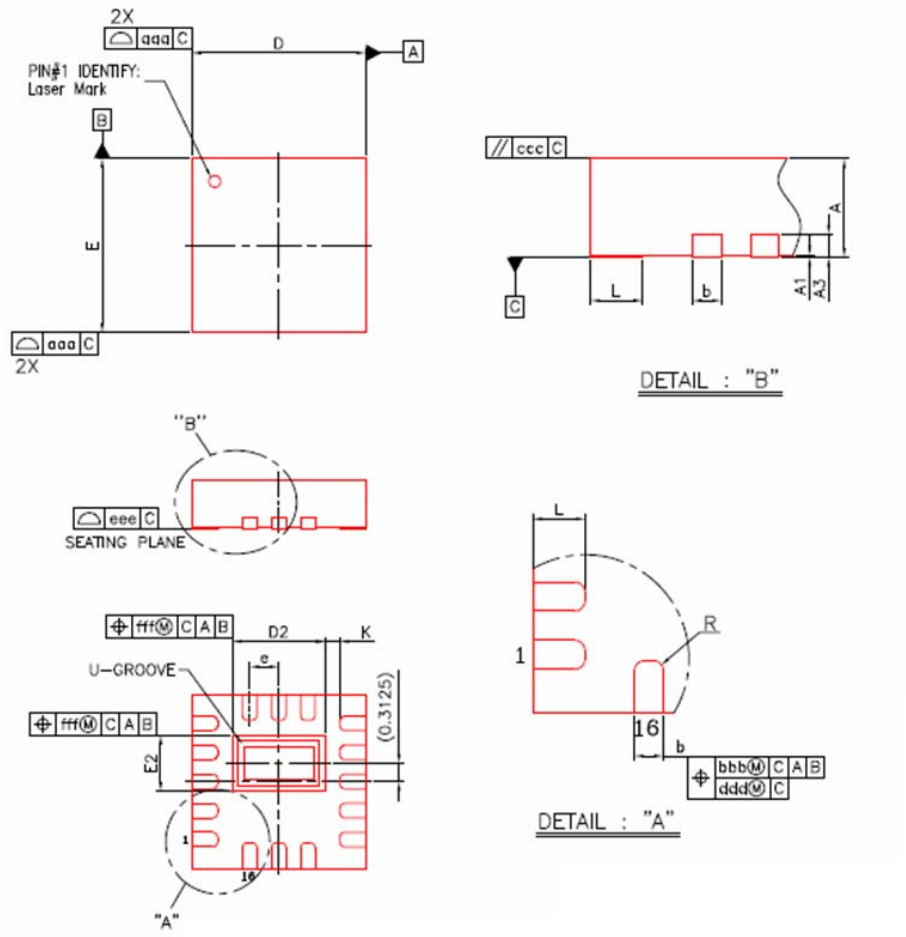




APPLICATION CIRCUIT



11. PACKAGE OUTLINE



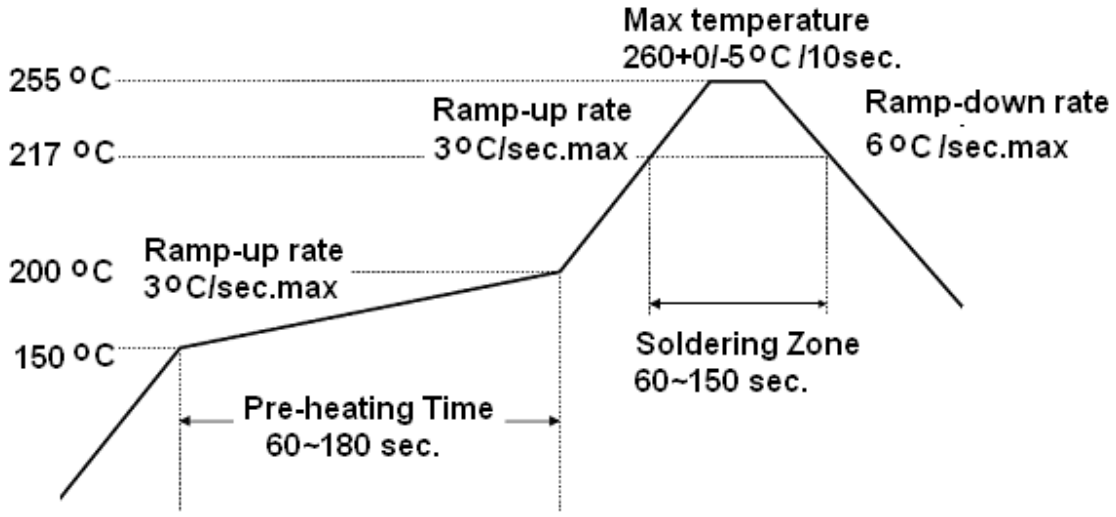
Symbol	Dimension in mm			Dimension in inch		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.80	0.85	0.90	0.031	0.033	0.035
A1	0.00	0.02	0.05	0.000	0.001	0.002
A3	0.20 REF			0.008 REF		
b	0.18	0.25	0.30	0.007	0.010	0.012
D/E	2.90	3.00	3.10	0.114	0.118	0.122
D2	1.45	1.60	1.75	0.057	0.063	0.069
E2	0.825	0.975	1.125	0.032	0.038	0.044
e	0.50 BSC			0.020 BSC		
L	0.35	0.45	0.55	0.014	0.018	0.022
K	0.20	---	---	0.008	---	---
R	0.09	---	---	0.0035	---	---
aaa	0.15			0.006		
bbb	0.10			0.004		
ccc	0.10			0.004		
ddd	0.05			0.002		
eee	0.08			0.003		
fff	0.10			0.004		

NOTE:

1. CONTROLLING DIMENSION : MILLIMETER
2. REFERENCE DOCUMENT: JEDEC MO-220.

11.1 Soldering Condition

1. Pb-free solder temperature profile



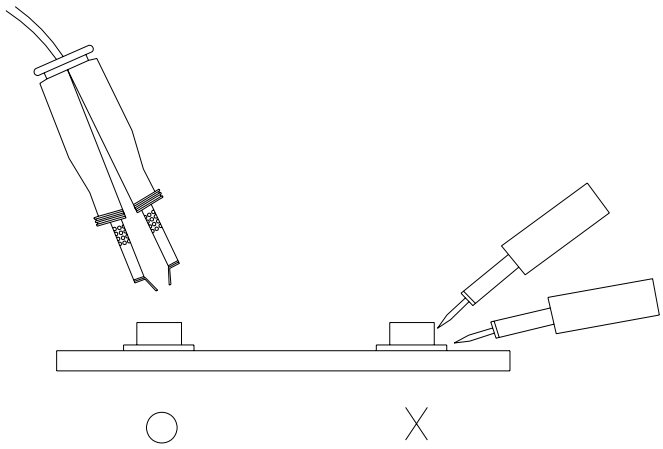
2. Reflow soldering should not be done more than two times.
3. When soldering, do not put stress on the ICs during heating.
4. After soldering, do not warp the circuit board.

11.2 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.

11.3 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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