STK8312

Digital Output 3-axis MEMS Accelerometer

Preliminary Datasheet

Version - 0.9.9
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Sensortek Technology Corporation

1. OVERVIEW

Description

The STK8312 is a ±1.5g/±6g/±16g, 3-axis linear accelerometer, with digital output (I2C). It is a very low power, low profile capacitive MEMS sensor featuring, compensation for 0g offset and gain errors, and conversion to 6/8-bit digital values at a user configurable samples per second. The device can be used for sensor data changes and orientation through an interrupt pin (/INT). The STK8312 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: 1.7V – 3.6V
- ±1.5g/±6g/±16g dynamically selectable full-scale
- I2C digital output interface and 1 interrupt pin
- 6/8 bit data output
- 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.
- Tilt Orientation Detection for Portrait/Landscape Capability
- Shake Detection
- Tap/Double Tap Detection
- Free Fall Detection
- RoHS Compliant
- Halogen Free
- Environmentally Preferred Product

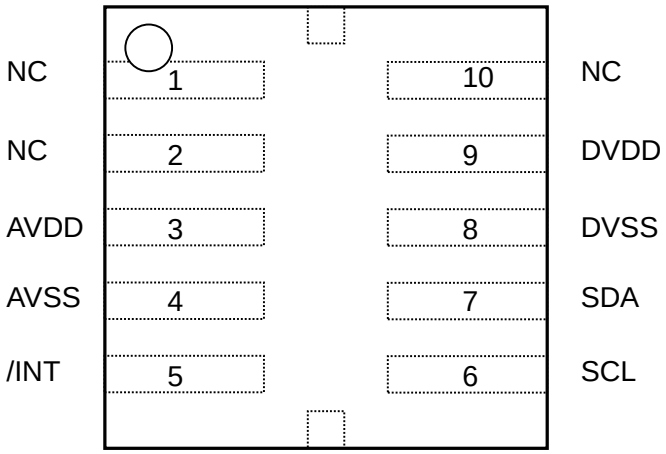
Applications

- 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

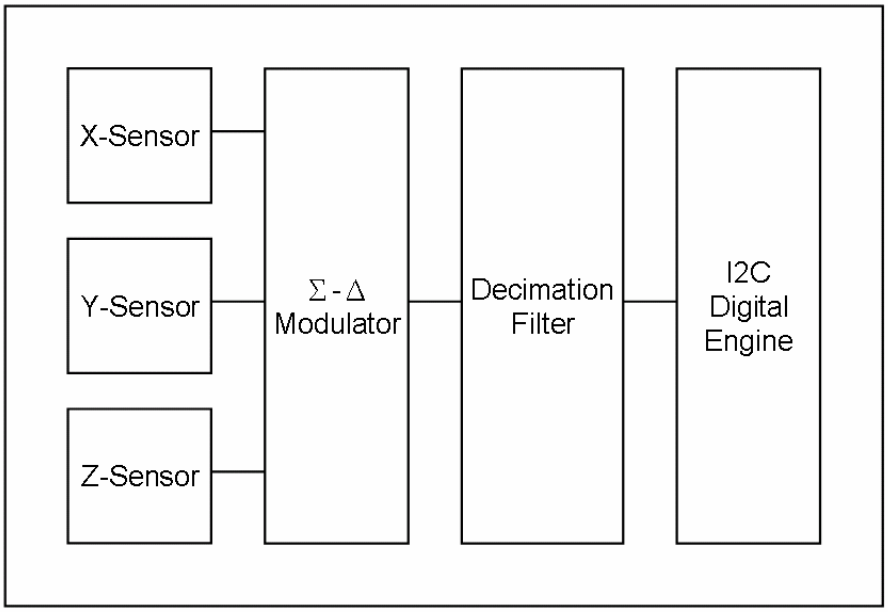
2. PIN DESCRIPTION

Pin#	Name	Function
1	NC	NC
2	NC	NC
3	AVDD	Analog Power
4	AVSS	Device Ground
5	/INT	Interrupt/Data Ready
6	SCL	I2C Serial Clock
7	SDA	I2C Serial Data (Open-Drain)
8	DVSS	Digital I/O Ground
9	DVDD	Digital Power
10	NC	NC

Top View



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 (VS)		2.4	2.8	3.6	V
Interface Voltage Range (VDD I/O)		1.7		3.6	V
Current consumption in active mode			184		µA
Current consumption in standby mode				1	µA
Digital high level input voltage (VIH)		0.7 x VDD I/O			V
Digital low level input voltage (VIL)				0.3 x VDD I/O	V
High level output voltage (VOH)[1]		0.8 x VDD I/O			V
Low level output voltage (VOL)[1]				0.2 x VDD I/O	V
OUTPUT DATA RATE AND BANDWIDTH	Each axis				
Output data rate (ODR)	in active mode	3.125		400	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		±1.5/±6/±16		g
Nonlinearity	Percentage of full scale		±0.28		%
Cross-Axis Sensitivity			±1		%
OUTPUT RESOLUTION	Each axis				
±1.5 g Range	Full resolution		6		Bits
±6 g Range	Full resolution		8		Bits
±16 g Range	Full resolution		8		Bits
SENSITIVITY	Each axis				
Sensitivity at XOUT, YOUT, ZOUT	±1.5g, 6-bit resolution	19.62	21.33	23.04	LSB/g
	±6g, 8-bit resolution	19.62	21.33	23.04	LSB/g
	±16g, 8-bit resolution	7	8	9	LSB/g
Sensitivity Change Due to Temperature	X-, Y-Axes		0.02		%/°C
	Z-Axis		0.02		%/°C
0 g OFFSET[1]	Each axis				
0 g Output for XOUT, YOUT, ZOUT			±50		mg
NOISE					
X-, Y-Axes and Z-Axis	±1.5g, 6-bit resolution ODR = 100Hz		±1		LSB
X-, Y-Axes and Z-Axis	±16g, 8-bit resolution ODR = 100Hz		±1		LSB

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
AVDD	Analog Supply voltage	-0.3 to 3.6	V
DVDD	Digital 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

Both I2C and SPI digital interface are available in STK8BA50. In both cases, the STK8BA50 operates as a slave device. PS (protocol select) pin state is used to select the operation interface. The I2C mode is enabled if the PS pin is tied high to VDDIO. and the SPI mode is enabled when the PS pin is tied to low.

7.1 I2C

All registers in STK8312 can be accessed via the I2C bus. All operations can be controlled by the related registers. There are two signals associated with the I2C 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 STK8312 without having to reset the entire I2C bus, an explicit reset command is provided. If register 0x20 is set to 0x00, STK8312 will reset all register and enter into standby mode. To reset STK8312 after power on is recommended.

In following timing chart, it is STK8312 I2C command format description for reading and writing operation between the host and STK8312.

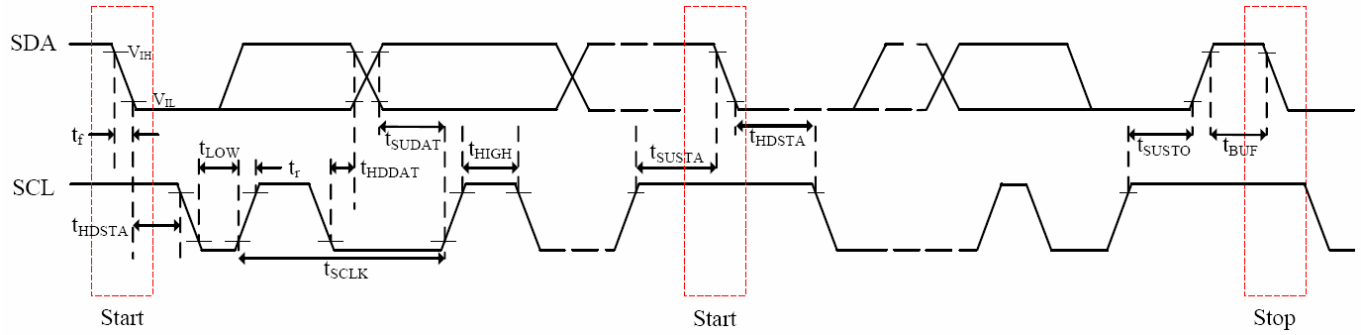
Slave Address
STK8312 provides the fixed slave address of 0x3D using 7-bit addressing protocol. In following table, it describes the command setting.

Slave Address (7-bit)	R/W Command Bit	OPERATION
0x3D (followed by the R/ W bit)	0	Write Data to STK8312
	1	Read Data form STK8312

Characteristics of the I2C Timing

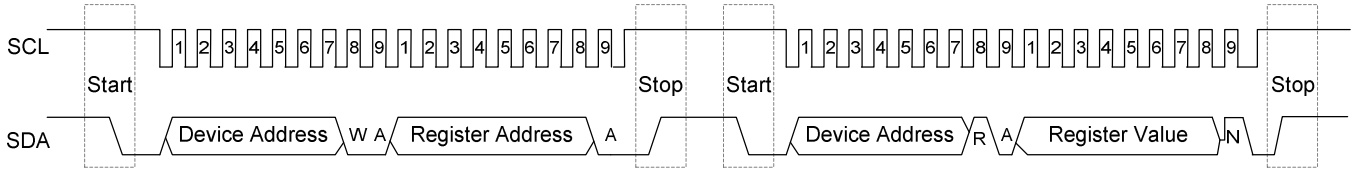
Symbol	Parameter	Standard Mode		Fast Mode		Unit
		Min.	Max.	Min.	Max.	
f_{SCLK}	SCL clock frequency	10	100	10	400	KHz
t_{HDSTA}	Hold time after (repeated) start condition. After this period, the first clock is generated	4.0	—	0.6	—	μs
t_{LOW}	LOW period of the SCL clock	4.7	—	1.3	—	μs
t_{HIGH}	HIGH period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

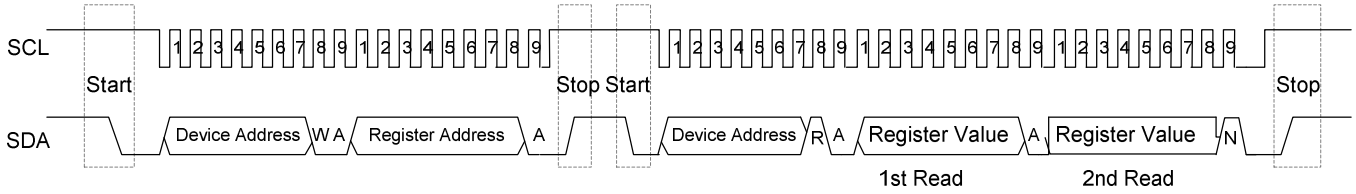


Timing Chart of the I2C

Write Command



Read Data



Sequential Read Data

8. PRINPICLE OF OPERATION

8.1 Mode of Operation

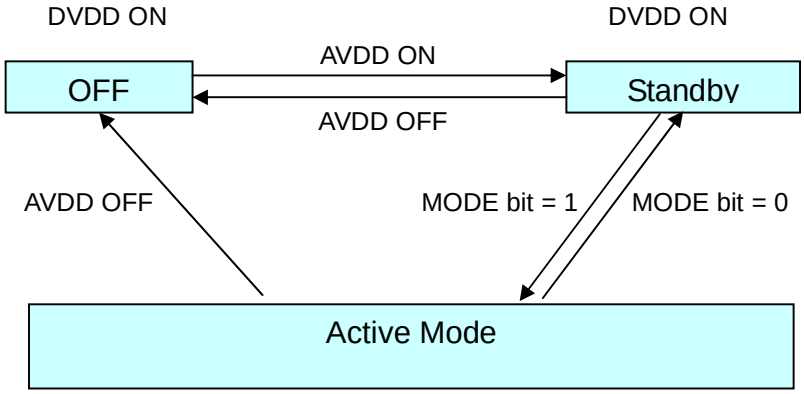
The sensor has three power modes: Off Mode, Standby Mode, and Active Mode to offer the customer different power consumption options. Only one mode could be acceptable at a time.

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 (0x07) control register by accessing the mode bit in the Mode register.

During the Active Mode, continuous measurement on all three axes is enabled. 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. Depending on the samples per second selected the power consumption will vary.

Measurement Mode	I²C Bus	DVDD	AVDD	Function
Off Mode	STK8312 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	STK8312 will respond to I2C bus	ON	ON	STK8312 is powered up in both supplies, so registers can be accessed normally to set STK8312 to Active Mode when desired. STK8312's sensor measurement system is idle.
Active Mode	STK8312 will respond to I2C bus	ON	ON	STK8312 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 XOUT (0x00), YOUT (0x01), and ZOUT (0x02) 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 (0x03) register, and FFAL, DTap in the SRST (0x04) register.

The Shake status always responds to any measurement data over shake threshold value (STH[2:0] in the STH (0x13) register), and 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 (0x09) register are enabled. The FFAL Status and Interrupt are controlled by FFINT in CTRL (0x14). 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 (0x06) and CTRL (0x14) 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

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.

9. REGISTER DEFINATION

Address	Name	Definition	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
$00	XOUT	6/8-bit output value X	Rev/XOUT[7]	Alert/XOUT[6]	XOUT[5]	XOUT[4]	XOUT[3]	XOUT[2]	XOUT[1]	XOUT[0]
$01	YOUT	6/8-bit output value Y	Rev/YOUT[7]	Alert/YOUT[6]	YOUT[5]	YOUT[4]	YOUT[3]	YOUT[2]	YOUT[1]	YOUT[0]
$02	ZOUT	6/8-bit output value Z	Rev/ZOUT[7]	Alert/ZOUT[6]	ZOUT[5]	ZOUT[4]	ZOUT[3]	ZOUT[2]	ZOUT[1]	ZOUT[0]
$03	TILT	Tilt Status	Shake	Alert	Tap	PoLa[2]	PoLa[1]	PoLa[0]	BaFro[1]	BaFro[0]
$04	SRST	Sampling Rate Status	0	0	0	0	FFAL	DTap	Reserved	AMSRS
$05	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
$06	INTSU	Interrupt Setup	SHINTX	SHINTY	SHINTZ	GINT	Reserved	PDINT	PLINT	FBINT
$07	MODE	Mode	IAH	IPP	Reserved	Reserved	Reserved	TON	Reserved	MODE
$08	SR	Portrait/Landscape samples per seconds and Debounce Filter	FILT[2]	FILT[1]	FILT[0]	Reserved	Reserved	AMSR[2]	AMSR[1]	AMSR[0]
$09	PDET	Tap Detection	ZDA	YDA	XDA	PDTH[4]	PDTH[3]	PDTH[2]	PDTH[1]	PDTH[0]
$0A	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
$0B	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
$0C	OFSX	X-Axis offset	OFSX[7]	OFSX[6]	OFSX[5]	OFSX[4]	OFSX[3]	OFSX[2]	OFSX[1]	OFSX[0]
$0D	OFSY	Y-Axis offset	OFSY[7]	OFSY[6]	OFSY[5]	OFSY[4]	OFSY[3]	OFSY[2]	OFSY[1]	OFSY[0]
$0E	OFSZ	Z-Axis offset	OFSZ[7]	OFSZ[6]	OFSZ[5]	OFSZ[4]	OFSZ[3]	OFSZ[2]	OFSZ[1]	OFSZ[0]
$0F	PLAT	Tap Latency	PLAT[7]	PLAT[6]	PLAT[5]	PLAT[4]	PLAT[3]	PLAT[2]	PLAT[1]	PLAT[0]
$10	PWIN	Tap Window	PWIN[7]	PWIN[6]	PWIN[5]	PWIN[4]	PWIN[3]	PWIN[2]	PWIN[1]	PWIN[0]
$11	FTH	Free-Fall Threshold	FTH[7]	FTH[6]	FTH[5]	FTH[4]	FTH[3]	FTH[2]	FTH[1]	FTH[0]
$12	FTM	Free-Fall Time	FTM[7]	FTM[6]	FTM[5]	FTM[4]	FTM[3]	FTM[2]	FTM[1]	FTM[0]
$13	STH	Shake Threshold	RNG[1]	RNG[0]	-	-	-	STH[2]	STH[1]	STH[0]
$14	CTRL	Control Register	-	-			AOI	-	FFINT	DPINT
$20	SWRST	Software Reset	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 (0x07) register must be set to 0, placing the device in Standby Mode.

$00: 6/8-bits output value X (Read Only)

XOUT — X Output

D7	D6	D5	D4	D3	D2	D1	D0
Rev/XOUT[7]	Alert/XOUT[6]	XOUT[5]	XOUT[4]	XOUT[3]	XOUT[2]	XOUT[1]	XOUT[0]
0	0	0	0	0	0	0	0

If the RNG[1:0] of STH register is clear, then D0~D5 is signed byte 6-bit 2's complement data with allowable range of +31 to -32. XOUT[5] is 0 if the g direction is positive, 1 if the g direction is negative. D6 is used as alert bit. 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. D7 is a reserved bit.

If the RNG[1:0] of STH register is set, then D0~D7 is signed byte 8-bit 2's complement data with allowable range of +127 to -128. XOUT[7] is 0 if the g direction is positive. 1 if the g direction is negative.

$01: 6/8-bits output value Y (Read Only)

YOUT — Y Output

D7	D6	D5	D4	D3	D2	D1	D0
Rev/YOUT[7]	Alert/YOUT[6]	YOUT[5]	YOUT[4]	YOUT[3]	YOUT[2]	YOUT[1]	YOUT[0]
0	0	0	0	0	0	0	0

If the RNG[1:0] of STH register is clear, then D0~D5 is signed byte 6-bit 2's complement data with allowable range of +31 to -32. YOUT[5] is 0 if the g direction is positive, 1 if the g direction is negative. D6 is used as alert bit. 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. D7 is a reserved bit.

If the RNG[1:0] of STH register is set, then D0~D7 is signed byte 8-bit 2's complement data with allowable range of +127 to -128. YOUT[7] is 0 if the g direction is positive. 1 if the g direction is negative.

$02: 6/8-bits output value Z (Read Only)
ZOUT — Z Output

D7	D6	D5	D4	D3	D2	D1	D0
Rev/ZOUT[7]	Alert/ZOUT[6]	ZOUT[5]	ZOUT[4]	ZOUT[3]	ZOUT[2]	ZOUT[1]	ZOUT[0]
0	0	0	0	0	0	0	0

If the RNG[1:0] of STH register is clear, then D0~D5 is signed byte 6-bit 2's complement data with allowable range of +31 to -32. ZOUT[5] is 0 if the g direction is positive, 1 if the g direction is negative. D6 is used as alert bit. 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. D7 is a reserved bit.

If the RNG[1:0] of STH register is set, then D0~D7 is signed byte 8-bit 2's complement data with allowable range of +127 to -128. ZOUT[7] is 0 if the g direction is positive. 1 if the g direction is negative.

$03: 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.

$04: 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

$06: 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.

$07: 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.

$08: 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 Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active 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 Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active 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 Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active 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 Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active 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 Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active 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 Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active 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 Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active 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 Mode **Tap Detection:** Tap Detection Mode operates under **200** Samples/Second in Active 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]
001	2 measurement samples at the rate set by AMSR[2:0] have to match before the device updates portrait/ landscape data in TILT (0x03) register.
010	3 measurement samples at the rate set by AMSR[2:0] have to match before the device updates portrait/ landscape data in TILT (0x03) register.

011	4 measurement samples at the rate set by AMSR[2:0] have to match before the device updates portrait/ landscape data in TILT (0x03) register.
100	5 measurement samples at the rate set by AMSR[2:0] have to match before the device updates portrait/ landscape data in TILT (0x03) register.
101	6 measurement samples at the rate set by AMSR[2:0] have to match before the device updates portrait/ landscape data in TILT (0x03) register.
110	7 measurement samples at the rate set by AMSR[2:0] have to match before the device updates portrait/ landscape data in TILT (0x03) register.
111	8 measurement samples at the rate set by AMSR[2:0] have to match before the device updates portrait/ landscape data in TILT (0x03) register.

$09: 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

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

$0C: 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 46.9mg/LSB at ±1.5g and ±6g modes or 125mg/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.

$0D: 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 46.97mg/LSB at ±1.5g and ±6g modes or 125mg/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.

$0E: 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 46.9mg/LSB at ±1.5g and ±6g modes or 125mg/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.

$0F: 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

$10: 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.

$11: 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.

$12: 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.

$13: 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

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.

RNG

The RNG register is two bits which is used to select measurement range and resolution. The following table lists the measurement range and resolution.

RNG[1:0]	RESOLUTION	MEASUREMENT RANGE
00	6 bits	±1.5 g
01	8 bits	±6 g
10	8 bits	±16 g
11	RESERVED	

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

$14: Control Register (Read/Write)

CTRL

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

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

$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

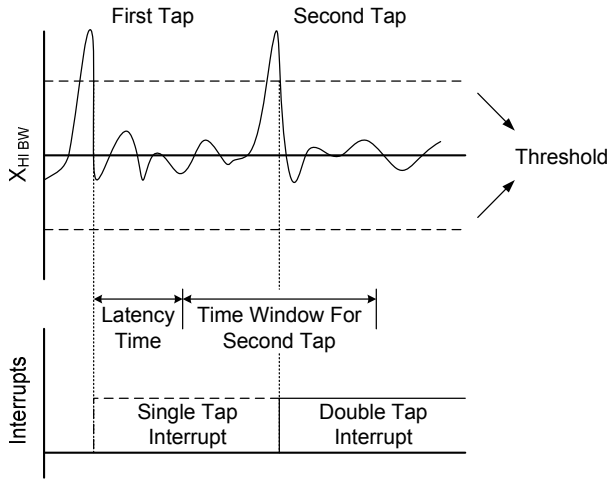
Set this register to 0x00 will reset STK8312 to standby mode, and all register will recover to default value. It's recommended that this register should be set to 0x00 after power on.

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 0x09).
- The tap latency time is defined by the latent register (Address 0x0F) 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 0x10).
- 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.

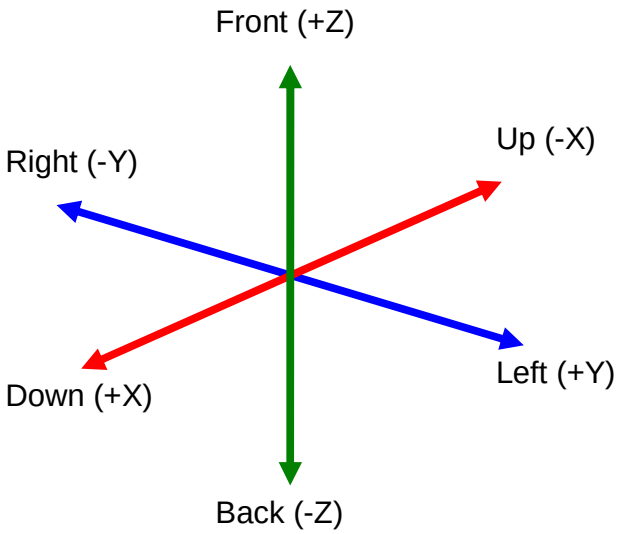
ORIENTATION DETECTION

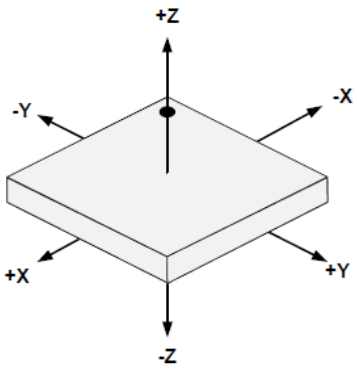
STK8312 gives the customer the capability to do orientation detection for such applications as Portrait/Landscape in Mobile phone/PDA/ PMP. The tilt orientation of the device is in 3 dimensions and is identified in its last known static position. This enables a product to set its display orientation 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 (0x03) 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 (0x03) register. These values are updated depending on the debounce filter settings (SR Register 0x08) 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 (0x08) 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 (0x03) register:

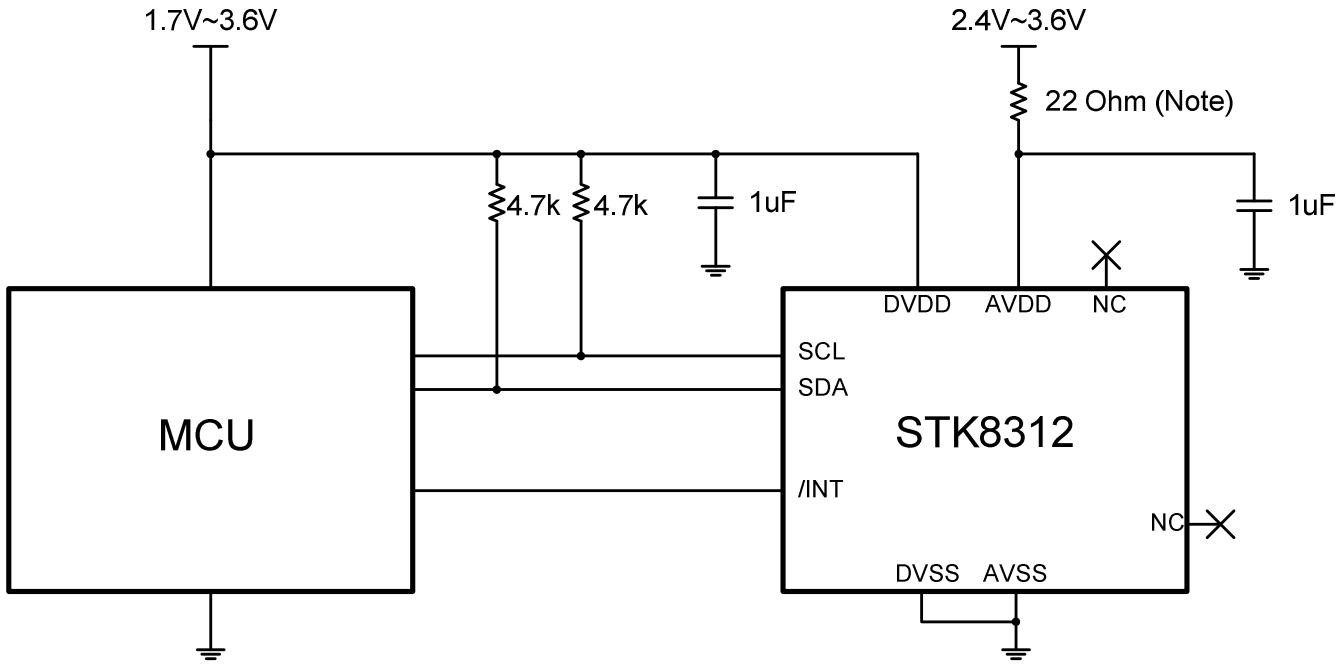
- If FILT [2:0] = 000, then the new values for Left, Right, Up, Down, Back, and Front are updated in the TILT (0x03) register (PoLa [2:0] and BaFro [1:0]) after every reading without any further analysis.
- If FILT [2:0] = 001 – 111, then the sensor requires the computed values for Left, Right, Up, Down, 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 (0x03) register (PoLa [2:0] and BaFro [1:0]). The debounce counter is reset after a mismatched reading or the TILT (0x03) 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





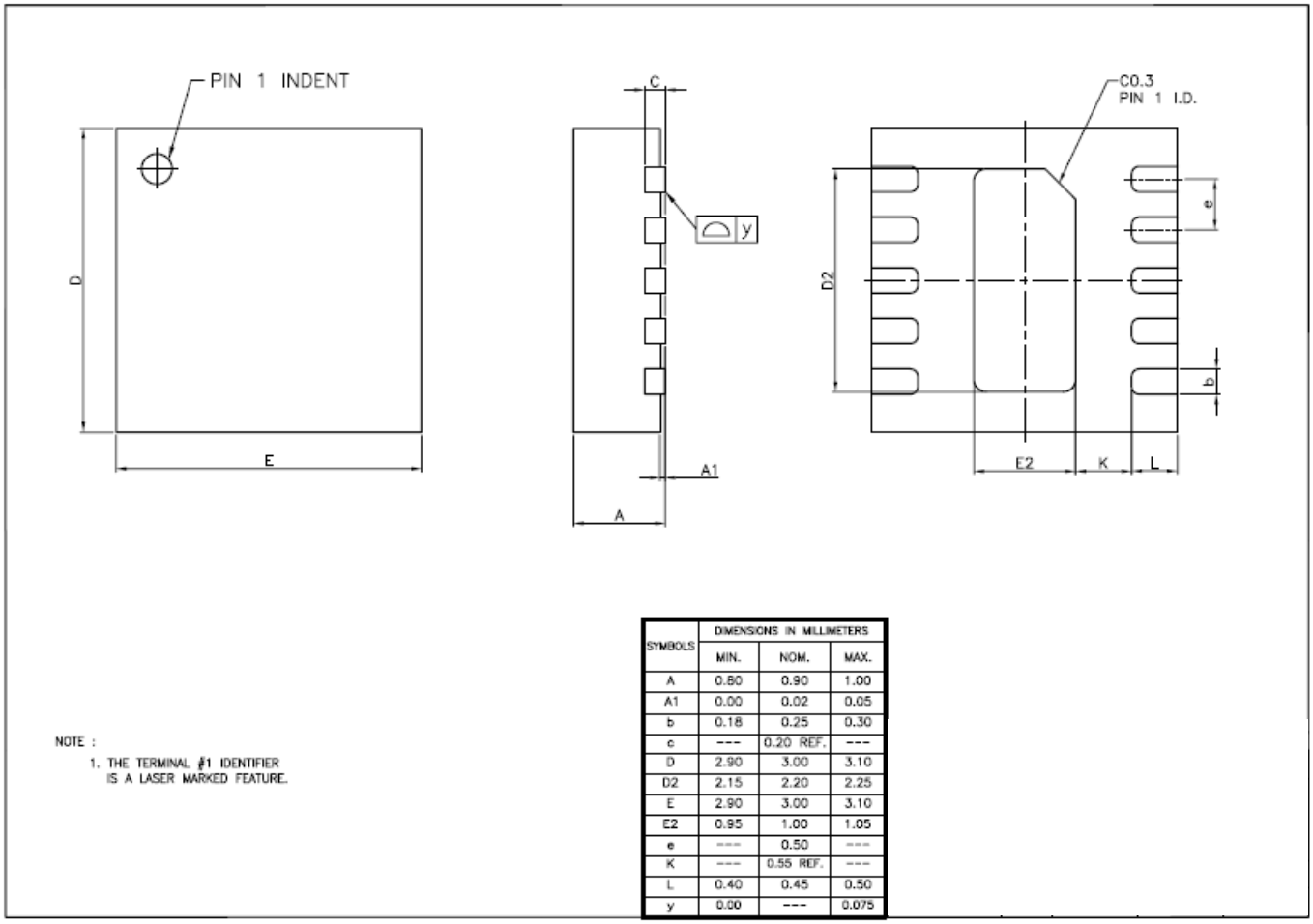
APPLICATION CIRCUIT



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

11. PACKAGE OUTLINE

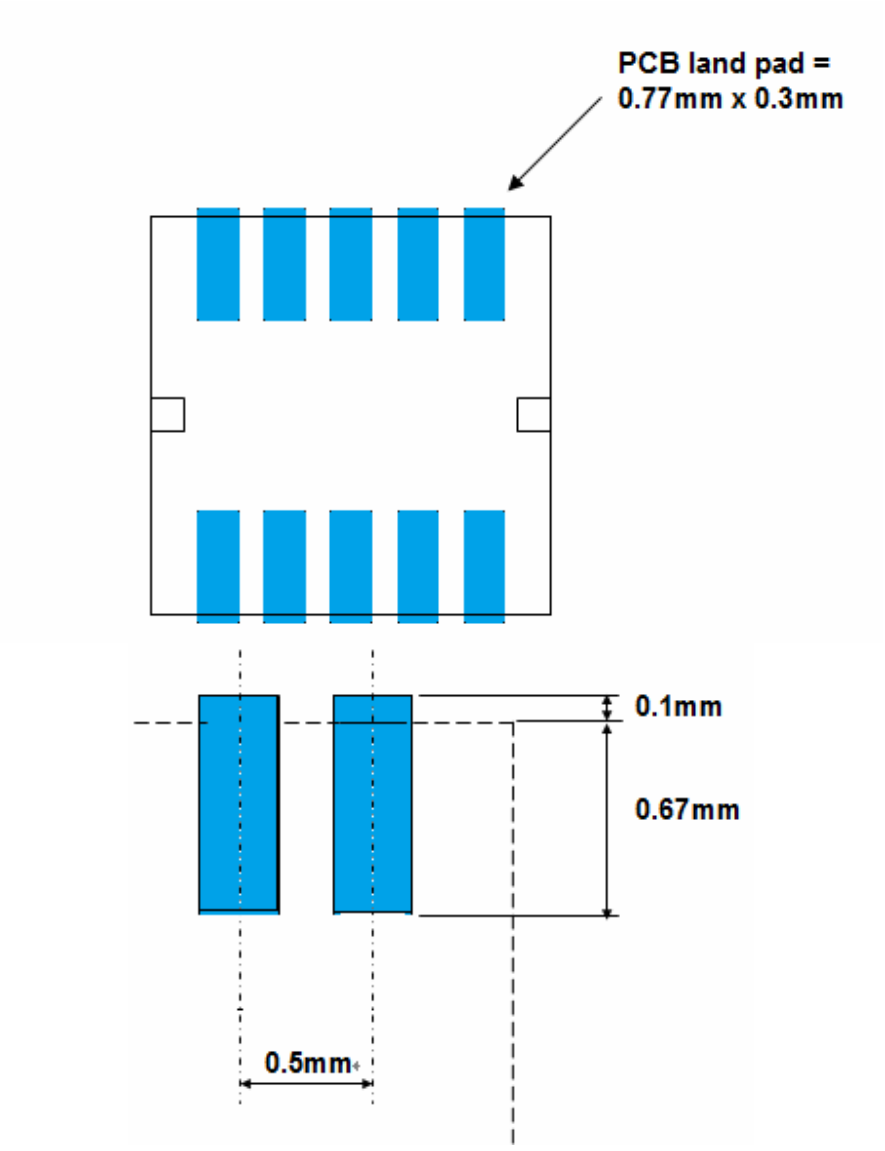
Package Outline Drawing



NOTE :
1. THE TERMINAL #1 IDENTIFIER IS A LASER MARKED FEATURE.

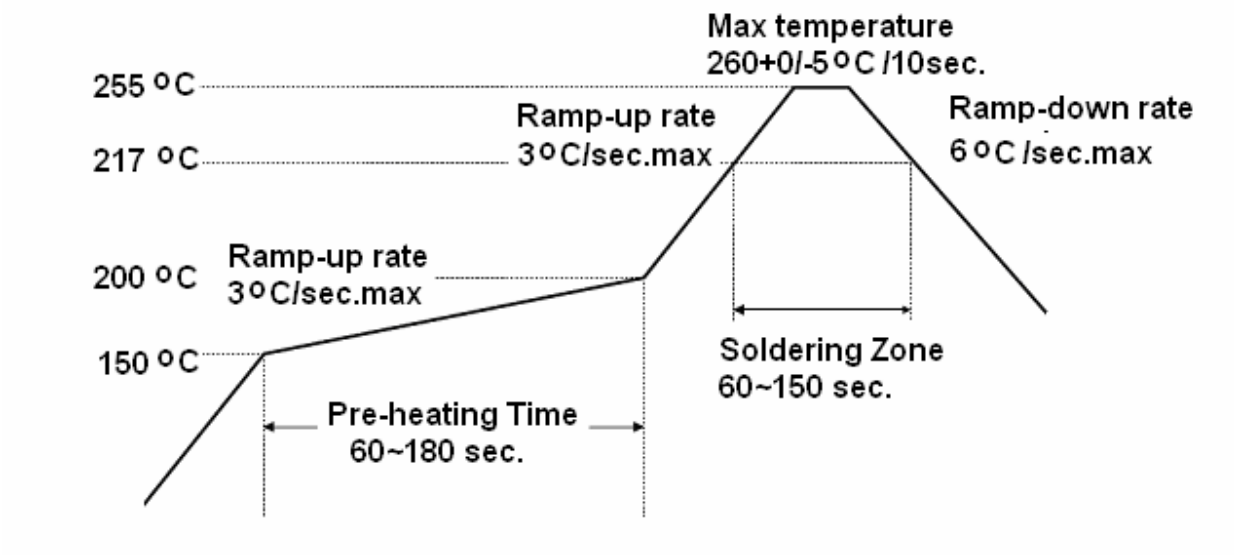
SYMBOLS	DIMENSIONS IN MILLIMETERS		
	MIN.	NOM.	MAX.
A	0.80	0.90	1.00
A1	0.00	0.02	0.05
b	0.18	0.25	0.30
c	---	0.20 REF.	---
D	2.90	3.00	3.10
D2	2.15	2.20	2.25
E	2.90	3.00	3.10
E2	0.95	1.00	1.05
e	---	0.50	---
K	---	0.55 REF.	---
L	0.40	0.45	0.50
y	0.00	---	0.075

Recommended PCB Layout



11.1 Soldering Condition

1. Pb-free solder temperature profile



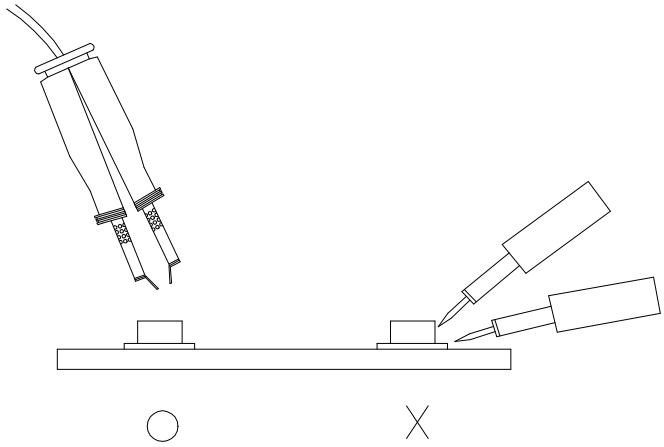
2. Reflow soldering should not be done more than two times.
3. When soldering, do not put stress on the ICs during heating.
4. After soldering, do not warp the circuit board.

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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