UM0704
User manual

STEVAL-MKI029V1: inclination analysis demonstration board based on the STM8S207R6 MCU and LIS331DLH MEMS

Introduction

This document explains the functioning of the STEVAL-MKI029V1 inclination analysis demonstration board based on STM8S207R6 MCU and LIS331DLH MEMS, and also serves as a quick reference manual to operate the system.

The STEVAL-MKI029V1 inclination analysis demonstration board is a hand-held demonstration board which detects the tilt on the X- and Y-axis of the board and provides a visual representation of this information using an array of colored LEDs placed in two circles. The demonstration board can detect the free-fall of the board and displays the information for this event on the bi-color LED at the center of the board. The system can also be configured to detect the circular motion of the board, in which LED patterns are generated depending on board movement. The STEVAL-MKI029V1 also features a demonstration mode. In this mode, different LED patterns are displayed irrespective of the position/motion of the board, making the system suitable for exhibitions and seminars.

Three modes of operation have been implemented. Each mode can be operated with or without the buzzer. An on-board button takes the demo from one mode to the next in a cyclic manner. The system automatically enters standby mode when there is no motion for more than 10 seconds and wakes up from standby when a vibration/motion is detected or the on-board button is pressed.

The STEVAL-MKI029V1 also monitors the batteries, and allows the user to check their status at any time. When low battery power is detected, the system alerts the user to change the batteries and the system enters into no-operation mode to avoid malfunction. The board is equipped with free MCU I/Os for the external interface, and a SWIM connector is included to provide in-circuit debugging capability. The system is powered by 3 AAA batteries of 1.5 V each. The board has a circular shape, with a diameter of 84 mm. The board is RoHS compliant.

To summarize, the key features of the system are:

- Detects and provides visual/audio representation of:
  - Tilt on the X-axis
  - Tilt on the Y-axis
  - Circular motion of the board
  - Free-fall motion of the board
- Displays motion information using multi-colored LEDs or music/rhythm patterns
- Provides six different operating modes
- Offers a standby function for low power consumption
- Monitors the 3 AAA batteries and displays their status on the LEDs
- Provides additional MCU I/Os for future extensions
- Equipped with a SWIM connector for debugging capability
- Compliant with RoHS directives

Contents

List of figures

1 Getting started

1.1 System requirements

The system requires 3 AAA batteries of 1.5 V each, totalling 4.5 V (1.5 X 3 = 4.5) for powering up the system.

1.2 Package content

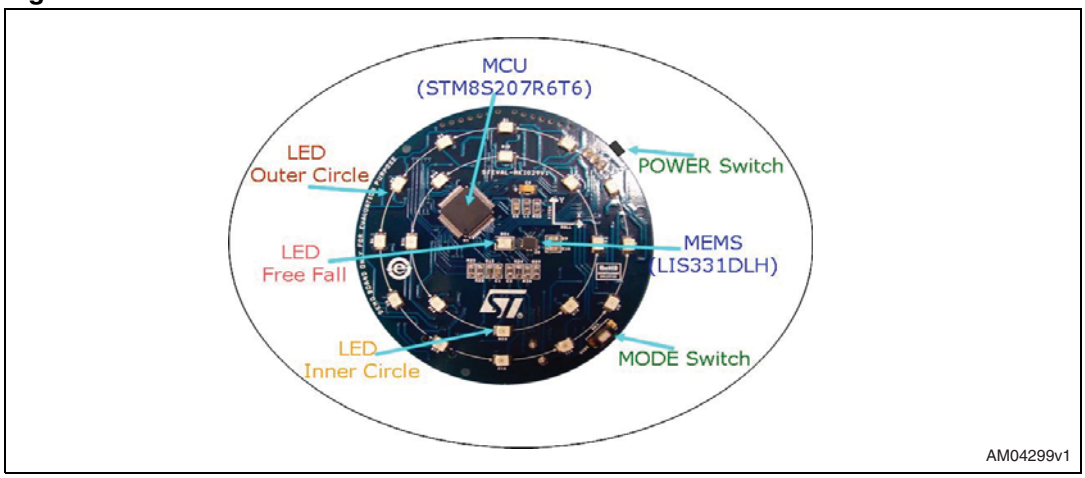
The demonstration board package includes the following:

- Hardware
  - STEVAL-MKI029V1
- Documentation
  - User manual

1.3 Hardware installation

The system can be powered up by using three AAA batteries of 1.5 V each.

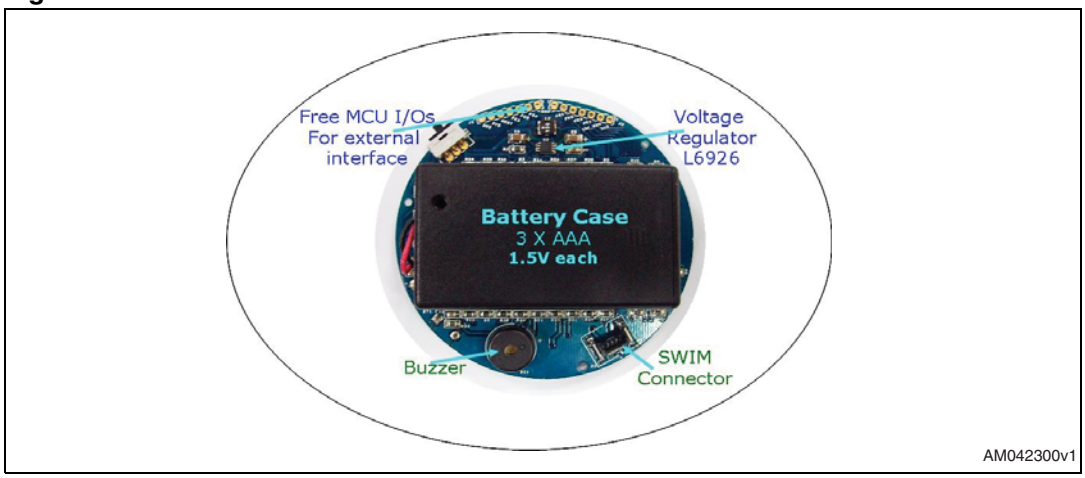
Figure 1. STEVAL-MKI029V1 - front view



The major components present on the STEVAL-MKI029V1 - front view, are (see *Figure 1*),

- Microcontroller - STM8S207R6T6
- MEMS - LIS33 DLH
- Power switch
- Mode switch
- Free-fall LED - bi-color LED (green/red)
- LED outer circle - 12 red colored LEDs in PLCC-2 package
- LED inner circle - 8 yellow colored LEDs in PLCC-2 package

Figure 2. STEVAL-MKI029V1 - back view



The major components present on the base station - back view, are (see *Figure 2*),

- Voltage regulator for regulated 3.3 V output - L6926
- SWIM connector - for the in-circuit programming of MCU STM8S207R6T6
- Battery case for holding 3 AAA (1.5 V) batteries
- Buzzer
- Free MCU I/Os for future expansion

1.4 Powering up the system

The system is powered up using the three AAA (1.5 V) batteries. These batteries should be placed into the battery case attached to the back of the board.

On the bottom side of the board, SW2 acts as the power switch where the user can switch the power to the system ON or OFF.

As the power switch is set to the ON position, the inner and outer circle LEDs glow in sequence. This pattern is referred to as the welcome message.

2 System operation

2.1 Starting up the system

When the system is powered up, the user is welcomed with a defined sequence of LED patterns. This indicates that the system has started up perfectly.

After this welcome message the system enters into the inclination mode, which is the default mode of the system. For details please refer to *Section 2.2*.

2.2 System operation modes

The system is equipped with 6 different modes of operation. These modes have different functions and the user can navigate through these modes by using the push button switch designated as 'MODE' and available on the top side of the board.

A detailed description of each mode follows:

2.2.1 Inclination mode

Inclination is the term which is used to describe the tilt of the system from the equilibrium position. The equilibrium position is the state when the board plane (MEMS X-Y plane) is parallel to the ground plane, i.e. the MEMS Z-axis is parallel to gravitational force 'G'. In equilibrium state all the outer and inner circle LEDs are off.

In this mode, both the tilt in the X-axis and the Y-axis of the board is measured and this information is displayed using the LED circles.

Tilt on the X-axis

If the Y-axis of the board/MEMS is kept fixed, the board is tilted on the X-axis (see *Figure 3* and *4*) then the system measures the tilt on the X-axis and this information is shown using the LEDs on the outer circle of the board.

Figure 3. Tilt on the X-axis: image of the board's X- and Y-axis

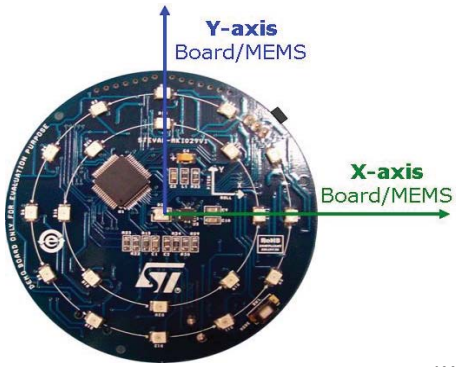
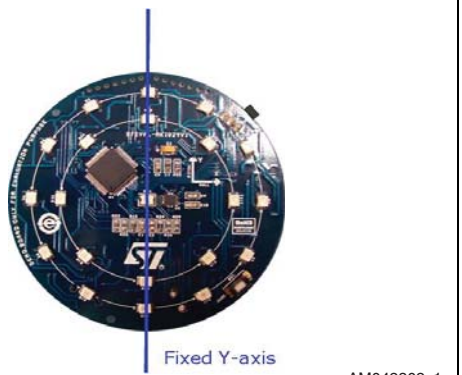


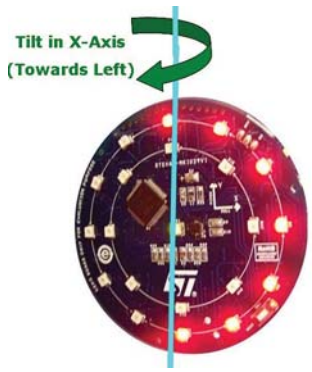
Figure 4. Tilt on the X-axis - image of the explanation of tilt on the X-axis



For example, let's suppose the board is in the equilibrium position and the Y-axis of the board is fixed, if the X-axis of the board is tilted in an upward/left direction, then at an inclination of, say, 14 degrees, D7 glows. If the inclination is increased further to 28 degrees, D5 and D9 are turned on. After that D3 and D11 are turned on and so on (see *Figure 5*). When the board is inclined at a right angle (the X-axis of the board is at 90 degrees to ground plane), all the outer circle LEDs are turned on. The LEDs start turning off in the same fashion when the board detects a reverse movement. ([D6], [D4, D8], [D2, D10], [D1, D12] and so on).

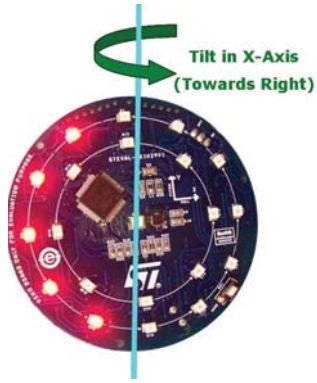
Similarly, starting from the equilibrium position, while keeping the Y-axis of the board fixed, if the X-axis of the board is tilted downwards/right, the outer circle LEDs start glowing beginning from D6. At an inclination of, say, 14 degrees, D6 glows. If the inclination is increased further to 28 degrees, D4 and D8 are turned on. After that D2 and D10 are turned on and so on (see *Figure 6*). When, the board is inclined at a right angle (the X-axis of the board is at 90 degrees to ground plane), all the outer circle LEDs are turned on. The LEDs start turning off in the same fashion when the board detects a reverse movement ([D7], [D5, D9], [D3, D11], [D1, D12] and so on)

Figure 5. Tilt in the X-axis in a left direction



AM042303v1

Figure 6. Tilt in the X-axis in a right direction



AM042304v1

Tilt on the Y-axis

If the X-axis of the board/MEMS is kept fixed, the board is tilted on the Y-axis (see *Figure 7* and *8*), then the system measures the tilt on the Y-axis and this information is shown using the LEDs on the inner circle of the board.

Figure 7. Tilt on the Y-axis - image of the board's X- and Y-axis

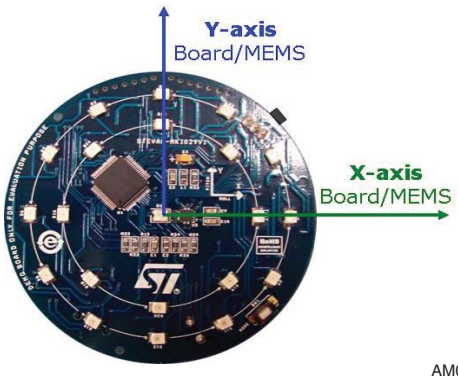
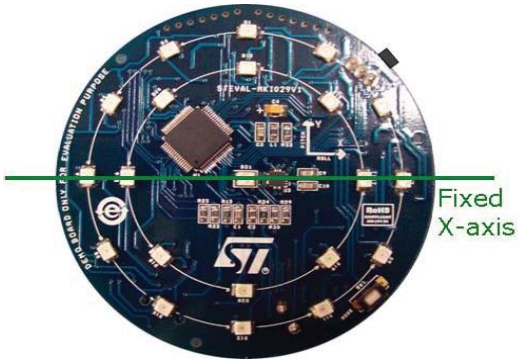


Figure 8. Tilt on the Y-axis - image of the explanation of tilt in the Y-axis



For instance, let's suppose the board is in an equilibrium position and the X-axis of the board is fixed, if the Y- axis of the board is tilted in an upward direction (the Y-axis of the board is moved up) then, at an inclination of, say, 18 degrees with respect to ground plane, D13 glows. If the inclination is increased to approximately 36 degrees, D14 and D15 glow (see *Figure 9*). If the inclination is further increased, D16, D17 are turned on, and then D18, D19 and when the board is finally perpendicular to the ground plane all the inner circle LEDs are turned on. The LEDs start turning off in a similar manner when the board detects a reverse tilt to again attain the equilibrium position, ([D20], [D18, D19], [D16, D17] and so on).

Similarly, let us suppose that from the equilibrium position, keeping the X-axis of the board fixed, if the Y-axis of the board is tilted downwards (the Y-axis of the board is moved down), the inner circle starts glowing, beginning from D20. If the board is inclined further in a downward direction, D19 and D18 turn on and so on (see *Figure 10*). When the board is at 90 degrees to the ground plane, all the inner circle LEDs are turned on. The LEDs start turning off in a similar manner when the board detects a reverse movement to again attain the equilibrium position, ([D13], [D14, D15], [D16, D17] and so on).

Figure 9. Tilt in the Y-axis in an upward direction

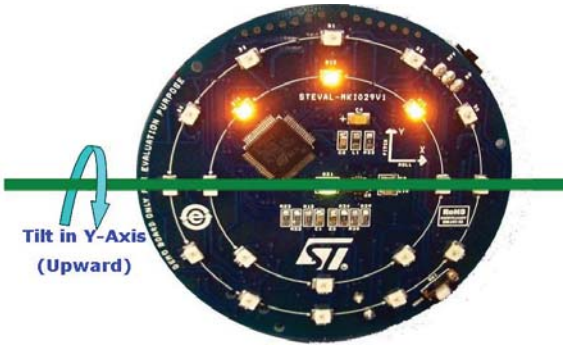
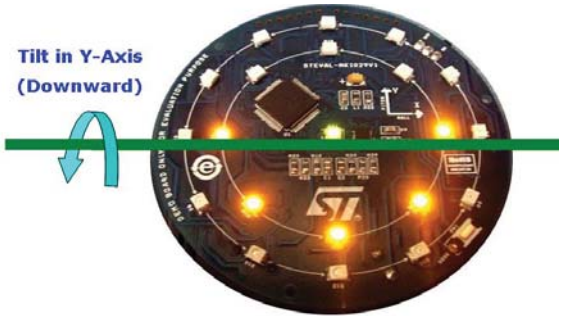


Figure 10. Tilt in the Y-axis in a downward direction



For a simultaneous tilt in both the X- and Y-axis, the combined effect is shown in the outer and inner LED circles of the board.

Note: The angles shown above are only for reference, these do not refer to the actual angle of inclination of the board in any axis.

Note: Tilt on the X- and Y-axis of the board is mentioned in the PCB of the board as the Roll and Pitch respectively. These do not refer to the pitch and roll of the gyroscope but are used just for this board

2.2.2 Inclination mode with sound

This mode also measures the tilt of the board in the X-axis and the Y-axis and displays this information on the LED circles. But in this mode, according to the motion, a sound is also produced using the buzzer. The frequency of the sound is related to the inclination/tilt of the board. The higher the inclination; the higher the beep sound frequency generated.

Beep sound frequencies for tilt in the Y-axis are kept higher than beep sound frequencies for tilt in the X-axis. This is done to distinguish the two motions also by the sound produced.

Note: For simultaneous angular movement in both the X- and Y-axis, the combined effect is shown in the outer and inner LED circles of the board, so, accordingly, the sound produced has the combined effect.

Note: To know more about the inclination measurement and display please see Section 2.2.1.

2.2.3 Circular mode

In this system mode the circumference of the board is divided into 12 directions and each LED on the outer circle denotes one such direction. Now, if the Z-axis of the board detects a tilt in any of these directions, then the corresponding LED on the outer circle and an opposite LED on the inner circle glows. The LEDs continue to glow until the board is inclined in that direction. Now, if the tilt direction is changed then the LEDs corresponding to that tilt start glowing.

This system mode is extended to show the circular motion of the board. To produce the circular motion of the board the user should follow the following steps:

- Hold the board in one palm with the XY plane of the board parallel to the palm
- Hold the hand in such a way that the back of the palm is facing the ground plane
- Now keeping the Z-plane of the hand fixed, revolve the hand in the XY plane (see *Figure 11*)

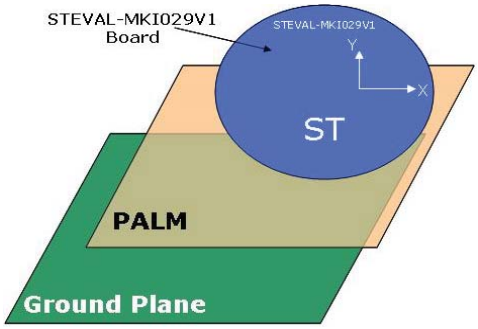
The LEDs on the boards follow the revolution of the board. If the revolution speed is high then it provides a very good visual effect of the rotating LEDs responding to the board revolution.

2.2.4 Circular mode with sound

This mode is similar to the circular mode described earlier in *Section 2.2.3*. But in this mode a buzzer sounds according to the motion of the board. Each of the 12 directions of the board is assigned a buzzer frequency, therefore producing a rhythmic sound effect with the circular motion of the board.

Figure 11. Circular mode

Two LEDs glowing at a time in circular mode



Graphic picture of the planes for the circular mode

Actual picture of the board in palm along with the ground plane

AM042309v1

2.2.5 Demonstration mode/whirl mode

This mode is specially developed for seminars and exhibitions. This mode does not take into account the motion/movement of the board. In this mode, at a particular moment, only a single LED glows. Let's call it the "running LED". The running LED starts from D19 of the inner circle and follows a clockwise motion at a certain predefined speed. The motion speed of the running LED continues to increase and at a particular speed the running LED leaves the inner circle and reaches the outer circle. The running LED starts from the outer circle at D6 and again follows a clockwise motion at a particular speed. The speed of the circular motion continues to increase at a particular rate and the running LED again starts from the inner circle LED D11.

Note: The above sequence continues to repeat until the user enters an alternative mode or the supply is turned off.

2.2.6 Demonstration mode/light and sound mode

This mode is also specially developed for seminars and exhibitions. In this mode different kinds of musical notes have been developed and the LEDs blink according to the musical notes.

Note: The above sequence continues to repeat until the user enters an alternative mode or the supply is turned off.

2.3 Battery life monitoring

The system is continuously monitoring the battery life and the user can check the present status of the battery at any time by pressing the mode switch twice (maximum 800 ms between two consecutive key presses). The higher the number of LEDs glowing; the more battery life remains (see *Figure 12*).

Figure 12. Battery status

When the battery voltage falls below 3.2 V, the system gives a low battery warning in which all the LEDs turn off and the complete system goes into low power mode. The system does not operate from the low power mode. This is an indication to the user that the batteries need to be replaced immediately. The system doesn't work until the batteries are replaced.

Note: The display levels are just to indicate to the user the battery life which is capable of running the system successfully.

2.4 Free-fall detection

The system is capable of detecting the free-fall of the board. Normally, the central D21 LED of the board is green. As the board is given a free-fall motion, the system produces a warning sound and the bi-color LED turns red. The inner circle blinks five times after the free-fall motion is detected. After the board has recovered from the free-fall motion, the bi-color LED turns green.

Note: The system only recognizes the free-fall of the board and rejects a forceful throw.

2.5 Standby operation

The system is provided with smart intelligence to save power. If the system is not disturbed or doesn't detect any motion for more than 10 seconds, then the system switches into the standby mode. In this mode all the LEDs are OFF and the MEMS and MCU are at their low-power consumption configuration. The system is smart enough that, as soon as it detects any motion, it wakes up from standby and starts performing in the same mode in which it went into standby. The system can also be re-activated by pressing the mode switch.

Note: The standby operation of the system is not present in the demonstration modes. This is done for the continuous operation of the system in demonstration modes.

3 Schematic and bill of materials

Figure 13. Schematic

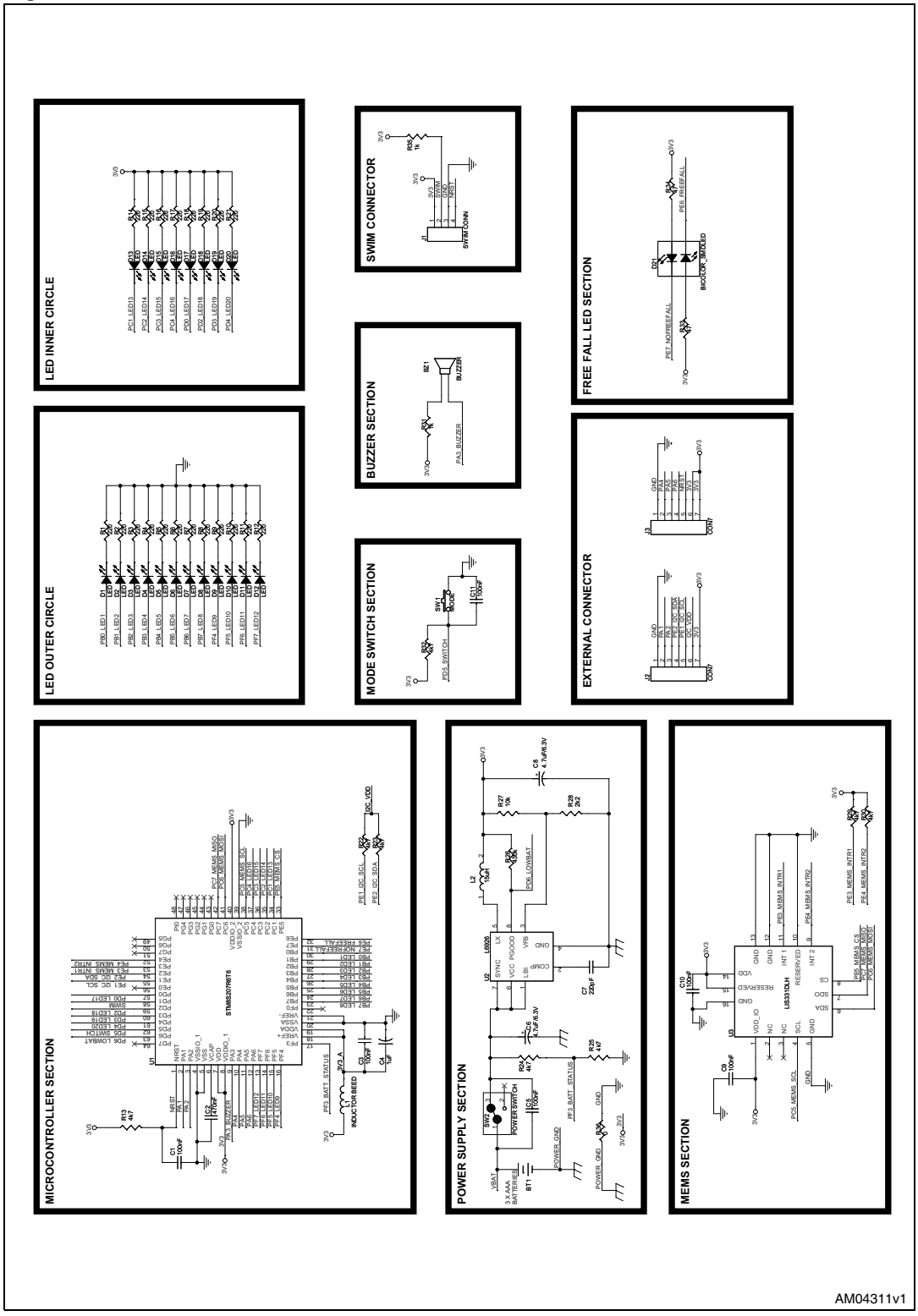


Table 1. BOM

Category	Ref. design.	Component descr.	Package	Manuf.	Manufacturer's ordering code / Orderable part number	Suppl.	Supplier ordering code
ST devices	U1	Microcontroller working as host for all the devices connected	LQFP-64, 10x10	STMicroelectronics	STM8S207R6T6	STMicroelectronics	STM8S207R6T6
	U2	Voltage regulator	MSOP8	STMicroelectronics	L6926	STMicroelectronics	L6926
	U3	MEMS	LGA16	STMicroelectronics	LIS331DLH	STMicroelectronics	LIS331DLH
Other devices	SW1	Push button switch used as 'MODE switch'	Through hole	Tyco Electronics	FSMH	Digi-Key	450-1646-ND
	SW2	Right angled slider switch used as power switch	Right angled through hole	EAO	09-10290-01	Farnell	674357
Connectors and jumpers	J1	SWIM connector	SMT, 4 pin, 1.27 mm pitch	ERNI	284697	ERNI	284697
	J2,J3	External jumpers for the free I/Os of STM8	Through hole	NA	NA	NA	NA
LEDs	D1,D2, D3,D4,D5,D6,D7, D8,D9, D10,D11,D12	Red LEDs of the outer circle	PLCC-2	Avago technologies US	HSMC-A101-S00J1	Digi-Key	516-2122-2-ND
	D13,D14,D15,D16,D17,D18,D19, D20	Yellow LEDs of the inner circle	PLCC-2	Avago technologies US	HSMA-A101-S00J1	Digi-Key	516-2120-2-ND
	D21	Bi-color LED for free-fall detection	PLCC-4	Kingbright	KAA-3528ESGC	Farnell	1318239

Table 1. BOM (continued)

Category	Ref. design.	Component descr.	Package	Manuf.	Manufacturer's ordering code / Orderable part number	Suppl.	Supplier ordering code
Capacitors	C7	220 pF	SMD0805	Xicon	140-CC501B221K-RC or equivalent	Mouser	140-CC501B221K-RC
	C1,C3, C5,C9,C10, C11	100 nF	SMD0805	Panasonic - ECG	ECJ-2VB1E104K or equivalent	Digi-Key	PCC1828CT-ND
	C2	470 nF	SMD0805	Murata Electronics North America	GRM21BF51E474ZA01L or equivalent	Digi-Key	490-1730-1-ND
	C4	1 µF	SMD1206	Panasonic - ECG	ECJ-3YB1C105K or equivalent	Digi-Key	PCC1882CT-ND
	C6,C8	Ceramic 4.7 µF 6.3 V	SMD 1206	Murata Electronics North America	GRM31MR60J475KC11L or equivalent	Digi-Key	490-3043-1-ND
Inductors	L1	Ferrite chip 600 Ω 200MA	SMD 0805	Murata Electronics North America	BLM21BD601SN1D	Digi-Key	490-1046-1-ND
	L2	15 µH	0.157" L x 0.157" W x 0.079" H (4.00 mm x 4.00 mm x 2.00 mm)	TDK	VLCF4020T-150MR68	Digi-Key	445-3187-1-ND

Table 1. BOM (continued)

Category	Ref. design.	Component descr.	Package	Manuf.	Manufacturer's ordering code / Orderable part number	Suppl.	Supplier ordering code
Resistors	R36	0	SMD0805	Bourns	CRL0805-JW-R100ELF or equivalent	Mouser	652-CRL0805JWR100ELF
	R33, R34	47 Ω	SMD0805	Xicon	260-47-RC or equivalent	Mouser	260-47-RC
	R1,R2,R3,R4,R5, R6,R7, R8,R9, R10 R11,R12, R14,R15, R16,R17, R18,R19, R20,R21	220 Ω	SMD0805	Xicon	260-220-RC or equivalent	Mouser	260-220-RC
	R31, R35	1 kΩ	SMD0805	Xicon	292-1.0K-RC or equivalent	Mouser	292-1.0K-RC
	R28	2.2 Ω	SMD0805	Xicon	292-2.2K-RC or equivalent	Mouser	292-2.2K-RC
	R13, R22, R23, R24, R25, R29, R30, R32	4.7 Ω	SMD0805	Vishay/Dale	CRCW08054K70JNEA or equivalent	Mouser	71-CRCW0805J-4.7K-E3
	R27	10 kΩ	SMD0805	Vishay/Dale	CRCW080510K0JNEA or equivalent	Mouser	71-CRCW0805J-10K-E3
	R26	430 kΩ	SMD0805	Xicon	260-430K-RC or equivalent	Mouser	260-430K-RC

Table 1. BOM (continued)

Category	Ref. design.	Component descr.	Package	Manuf.	Manufacturer's ordering code / Orderable part number	Suppl.	Supplier ordering code
Misc. components	BT1	Case for 3 X AAA batteries	63 mmx 37 mm (wired)	Eagle plastic devices	12BH431/C-GR	Mouser	12BH431/C-GR
			55 mmx 38 mm (wired)	Memory protection devices	SBH-431-1A	Digi-Key	SBH-431-A-ND
	BZ1	Buzzer	12.2 mmx 6.5 mm (through hole)	TDK	PSI240P02AT	Mouser	810-PS1240P02AT

4 Revision history

Table 2. Document revision history

Date	Revision	Changes
23-Apr-2010	1	Initial release.

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries (“ST”) reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST’s terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST’S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER’S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com