# UM0313
# User manual

## EK302DL
## Evaluation Kit

## Introduction

The EK302DL is an evaluation kit designed to provide the user with a complete, ready-to-use platform for evaluation of the LIS302DL. The LIS302DL is a low power 3-axis linear accelerometer with digital output. The device includes a sensing element and an IC interface capable of translating information from the sensing element into a measured signal that can be used for external applications.

In addition to the MEMS sensor, the evaluation board utilizes an ST7-USB microcontroller which functions as a bridge between the sensor and the PC, on which it is possible to use the Graphical User Interface included with the kit or dedicated software routines for customized applications.

This user manual describes the hardware included with the evaluation kit and provides the information required to install and run the evaluation kit user interface.

For details regarding the features of the LIS302DL sensor, please refer to the datasheet for this device and application note AN2335.

# Contents

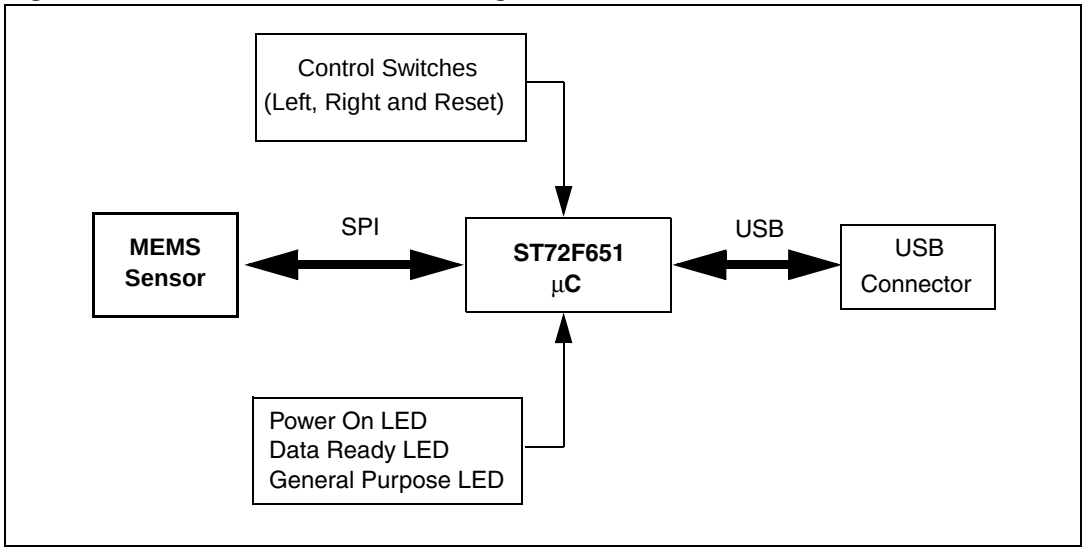
# List of figures

# 1 Evaluation kit description

The EK302DL is a complete evaluation kit that allows evaluation of the performance of the LIS302DL low power 3-axis linear accelerometer with digital output.

The block diagram of the evaluation kit is shown in *Figure 1*.

**Figure 1. Evaluation board block diagram**




The ST7-USB microcontroller included on the board allows communication between the sensor device and the PC. The user can interact with the hardware either through the GUI provided with the kit, or through dedicated software routines to run customized applications.

Switches and LED indicators are used to control and monitor the functionality of the board.

The top silk-screen view and photo of the full board, respectively, are shown in *Figure 2* and *Figure 3*.

**Figure 2. Top silk-screen of the EK302DL kit**

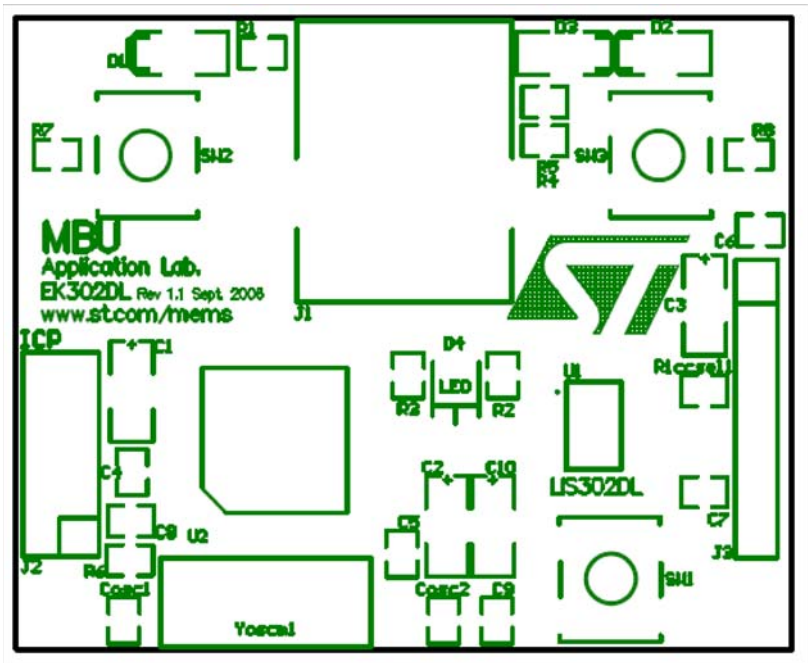
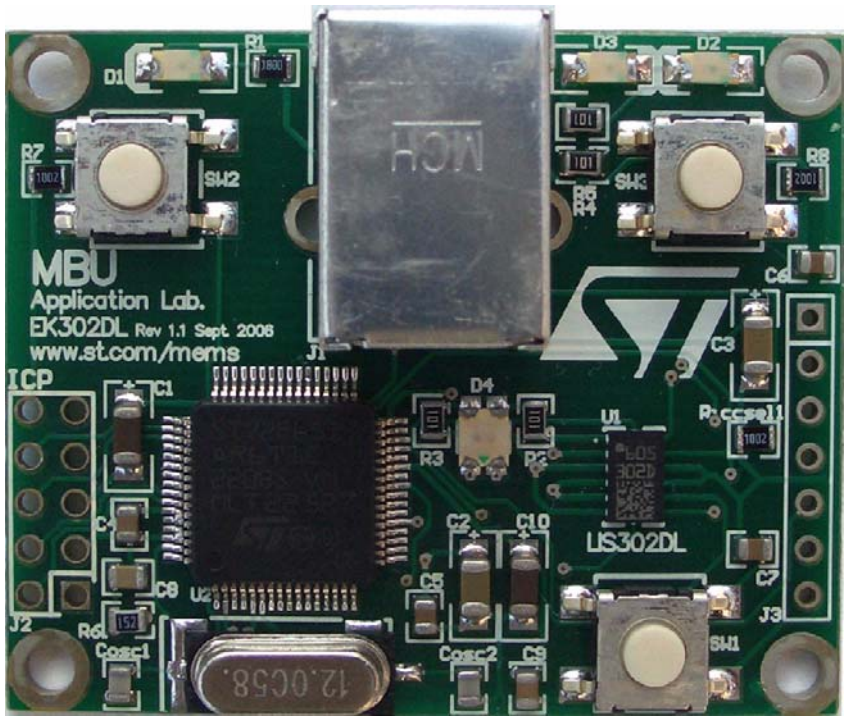



**Figure 3. Board photograph**




Operation of the EK302DL Evaluation Kit requires the installation of a dedicated driver which is included on the CD in the kit, together with a GUI interface which allows simple interaction with the sensor. The steps required for driver and software installation are described in the following section.

# 2 EK302DL GUI installation

The installation of the Graphical User Interface (GUI) for the EK302DL requires two steps:

1. installation on the PC of the software delivered with the evaluation kit.
2. installation of the Virtual COM driver needed to use the evaluation kit board.

## 2.1 PC system requirements

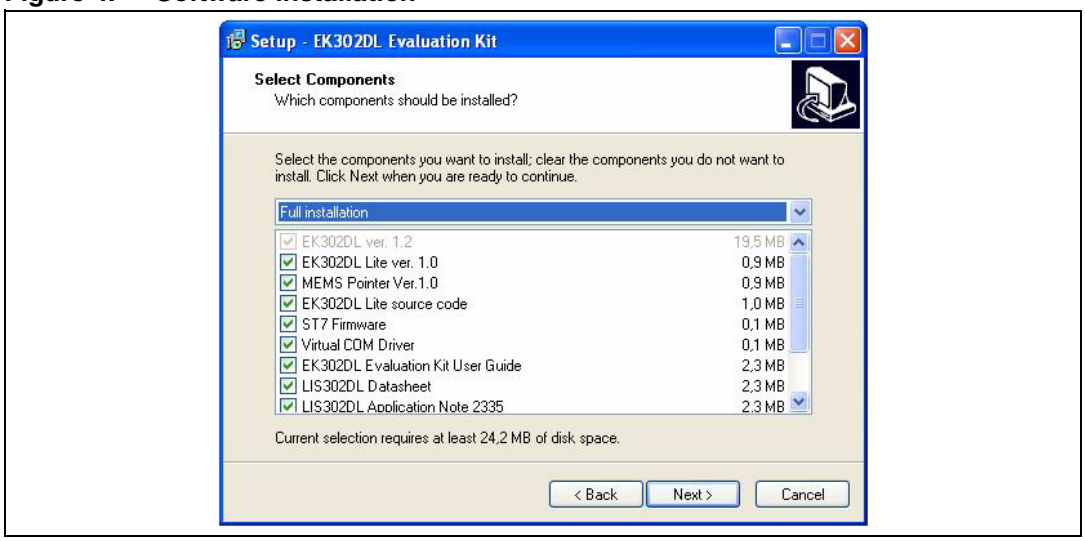
Both the hardware and software that compose the EK302DL Evaluation Kit have been designed to operate with Microsoft® Windows XP.

## 2.2 Software installation

To install the software distributed with the EK302DL Evaluation Kit:

1. insert the mini CD into the CD-ROM drive;
2. if the “Autorun” screen does not appear, click on Start > Run, then enter “D:\Autorun.exe” and click OK. “D” represents the letter of your CD-ROM drive;
3. click on “Evaluation Kit SW Installation” from the “EK302DL Evaluation Kit” page;
4. follow the on screen instructions (*Figure 4*).

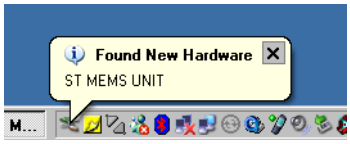
**Figure 4. Software installation**




## 2.3 Hardware installation

To install the virtual COM driver, insert the evaluation kit board into a free USB port. The “Notify” icon should appear as in *Figure 5*.

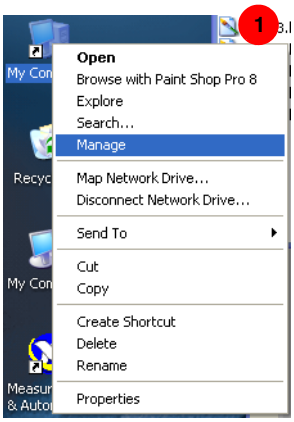
**Figure 5. Notify icon**




If the “Hardware Update Wizard” window appears (*Figure 7*), follow the instructions on the screen. Otherwise, the installation can be performed by following the instructions indicated in *Figure 6* and *Figure 7*.

**Figure 6. Driver installation using the device manager**

Right click on My Computer




Right click on “ST MEMS UNIT” and choose Update driver

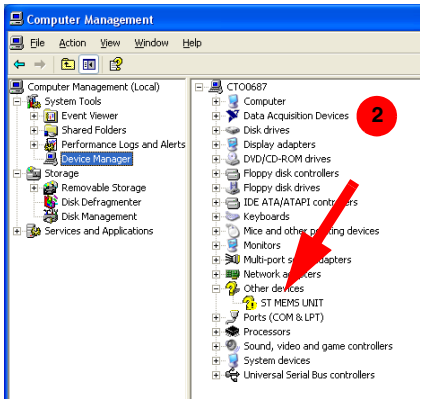
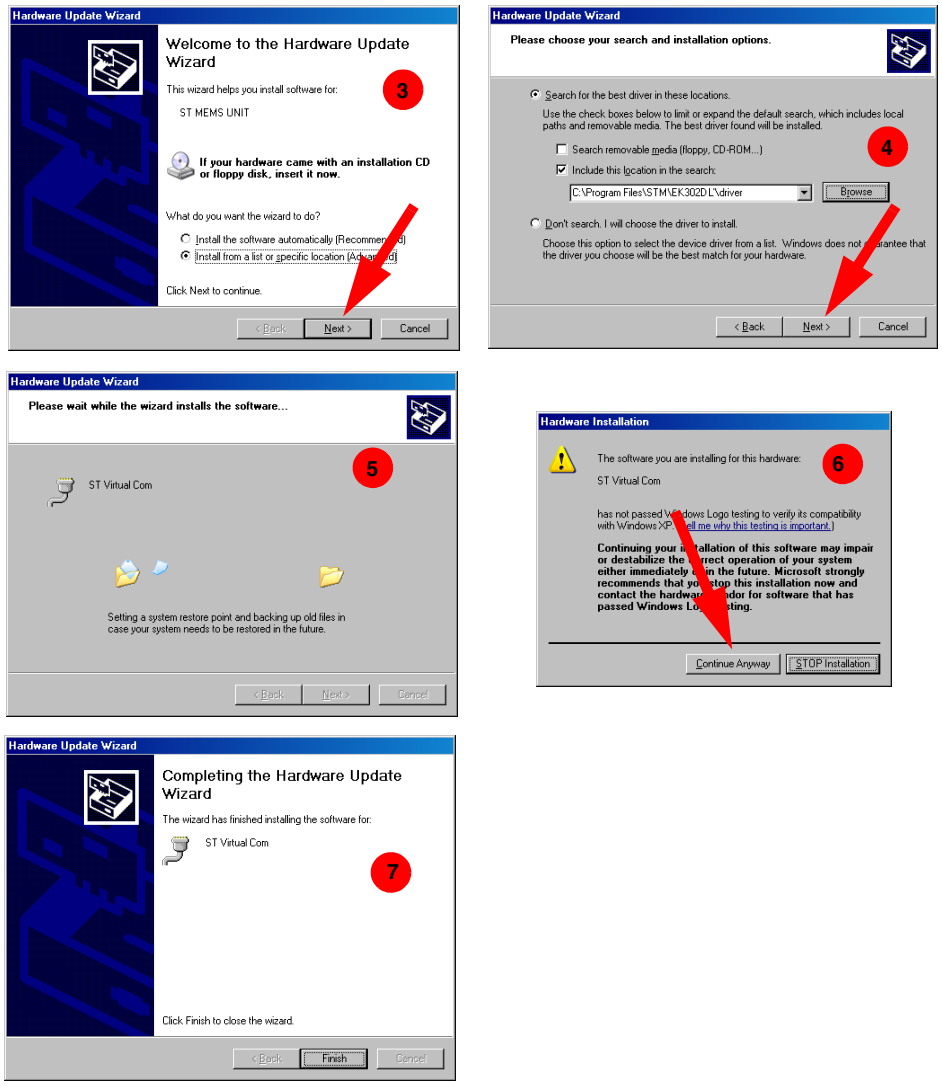
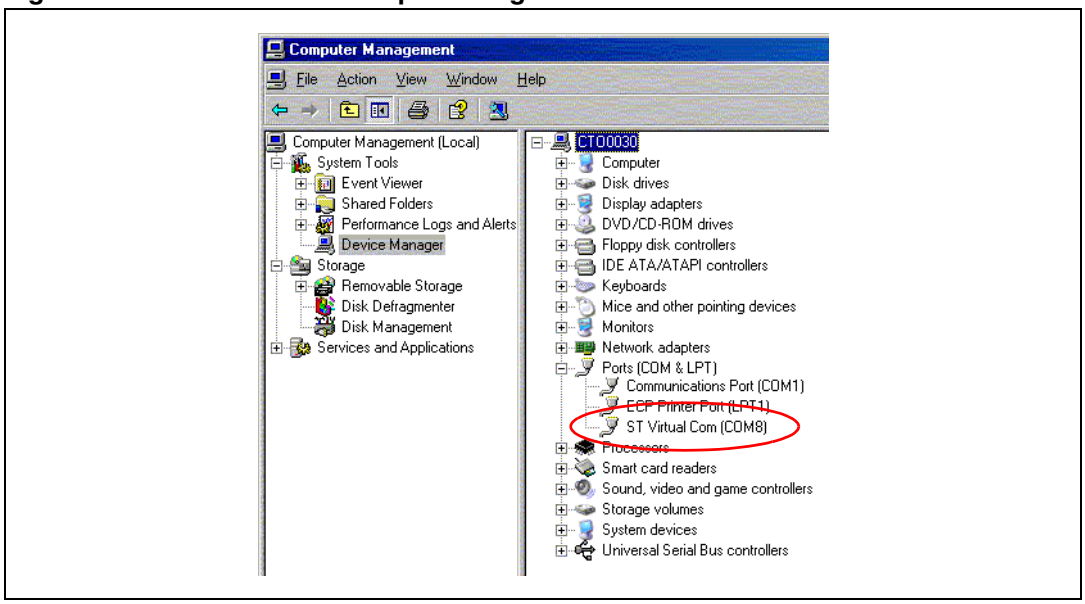


**Figure 7. USB driver installation using the Hardware Update Wizard**




Once the installation is complete, a COM port number will be assigned to the ST Virtual COM driver (*Figure 8*). This number should be retained as it will be required to run the EK302DL Evaluation Software GUI. For additional details, see section *3.1*.

**Figure 8. Virtual COM driver port assignment**



# 3 Graphical User Interface

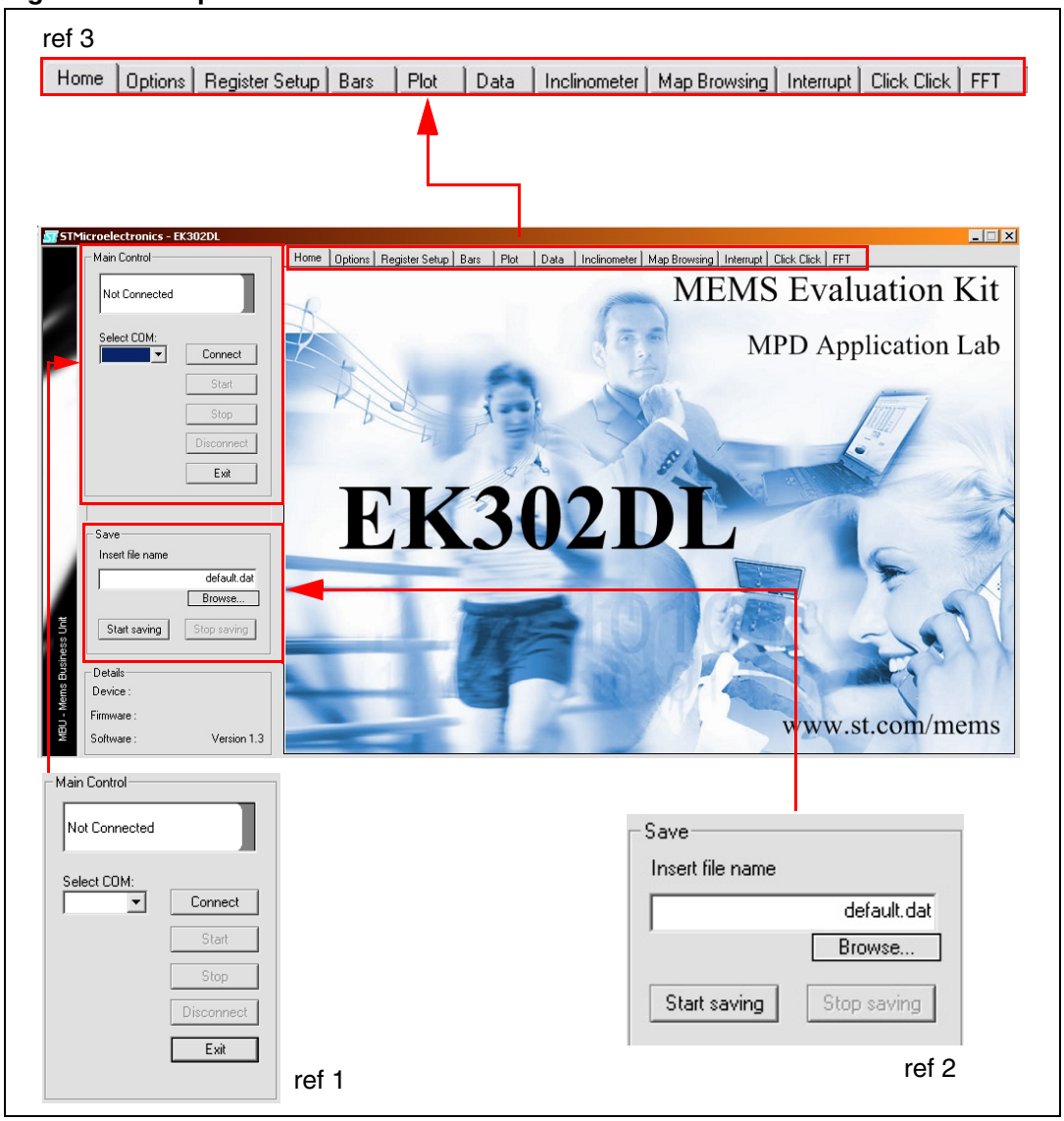
To execute the EK302DL Evaluation Software GUI:

1. click on Start > All Programs;
2. select EK302DL > Executables;
3. launch the program “EK302DL Ver.1.3”.

The GUI main window will appear as shown in *Figure 9*. The functions of the four main sections of the window are described below:

- Connection panel (ref 1) - Connects/disconnects the board and starts acquisition via the Start/Stop buttons.
- “Save” box (ref 2) - Allows the user to save the data to a specified file.
- Tab Menu (ref 3) - Used to toggle between the different functions of the evaluation kit.

**Figure 9. Graphical User Interface: main window**



## 3.1 Connecting to the Virtual COM port

Before using the functions of the evaluation kit software it is necessary to open the connection with the EK302DL board. This is achieved through the following procedure:

1. connect the EK302DL to the desired USB port;
2. in the “Select COM” drop-down menu (*Figure 9* ref 1), choose the Virtual COM number to which the board has been mapped. For additional information on how to obtain this number, see section *2.3*;
3. open the connection by clicking on “Connect” (*Figure 9* ref 1). When this procedure is complete, the general purpose LED on the board will switch from red to green.

At this point the user can acquire, plot and save the acceleration data measured by the sensor and access the content of the registers embedded in the device.

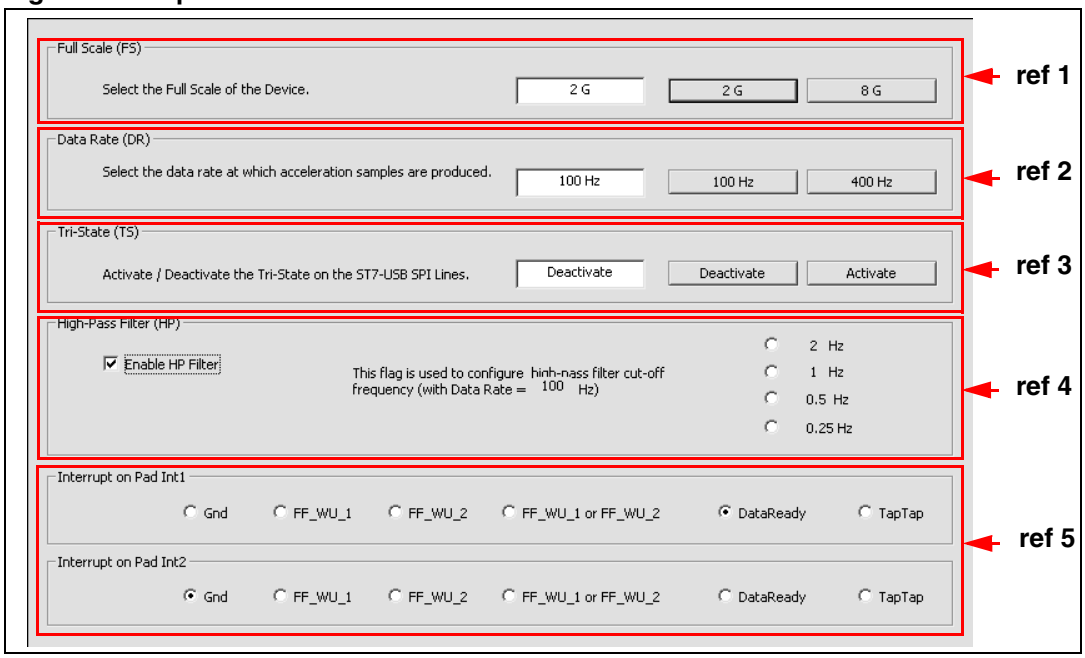
The following sections provide details regarding the functions of the tabs in *Figure 9*, ref 3.

## 3.2 “Options” tab

The Options tab allows the user to control the following parameters:

- Full Scale (FS) - Sets the maximum acceleration value measurable by the device. It is possible to select either 2g or 8g (*Figure 10*, ref 1).
- Data Rate (DR) - In this box the rate at which each acceleration sample is produced can be selected. The possible values are 100 Hz or 400 Hz (*Figure 10*, ref 2).
- Tri-State (TS) - Permits switching the SPI lines of the ST7-USB microcontroller mounted on the evaluation kit between 3-state (i.e. high-impedance) and normal mode (*Figure 10*, ref 3). This function makes it possible to isolate the sensor mounted on the board from the microprocessor, in case any external control (from a different microcontroller mounted on a separate user board) is needed.
- High-Pass Filter (HP) - This control activates the High-Pass Filter on the device and selects the cut-off frequency (*Figure 10*, ref 4).
- Interrupt on Pad IntX - Allows the selection of the type of signal to be sent out on Int1 and Int2 Pad (*Figure 10*, ref 5).

**Figure 10. Options tab**

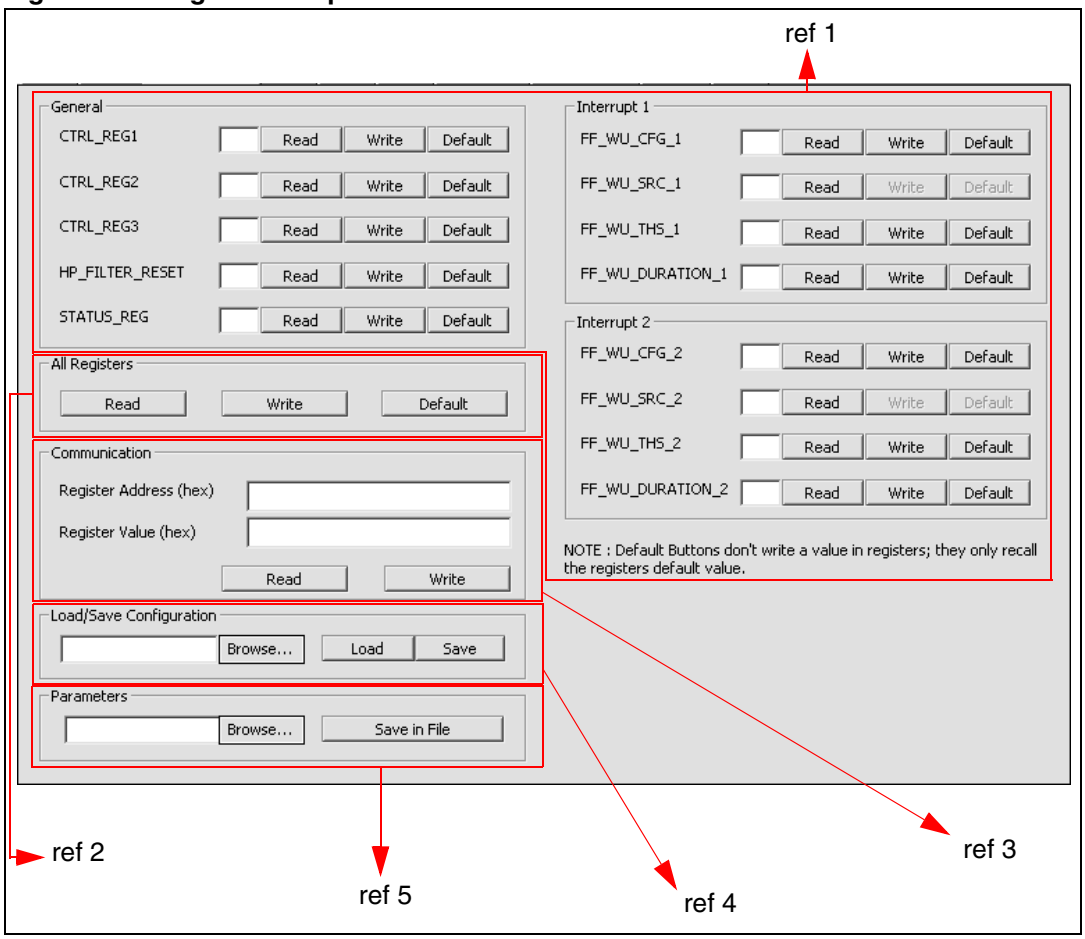



## 3.3 “Register Setup” tab

The Register Setup tab shown in *Figure 11* allows read/write access to the content of the registers embedded in the LIS302DL MEMS sensor mounted on the evaluation kit. The tab is divided into five sections:

- “General” (ref 1) - Provides access to the registers which control the main settings of the device. This section contains the control registers (CTRL_REG1, CTRL_REG2 and CTRL_REG3) and the registers that control the generation of inertial interrupt signals. It is possible to read and write the contents of each register. To restore the default value for a given register, press the “Default” button.
- “All Registers” (ref 2) - Permits the user to read, write and recall the default content for all the registers shown in ref 1 with a single click on the read/write/default button.
- “Direct Communication” (ref 3) - Provides access to any register in the device. To read a generic register, insert the address in the “Register Address” textbox, then click on the “Read” button. The retrieved content of the register will be displayed in the “Register Value” field. As with writing to a register, the user must specify the address and the data to be written inside the fields marked “Register Address” and “Register Value”, respectively, and then press the “Write” button.
- “Load/Save Configuration” (ref 4) - Lets the user save/load a specific configuration to/from a file.
- “Parameters” (ref 5) - Allows the user to save the register configuration to a text file, which includes a detailed description of the resulting configuration for each register.

**Figure 11. Register Setup tab**

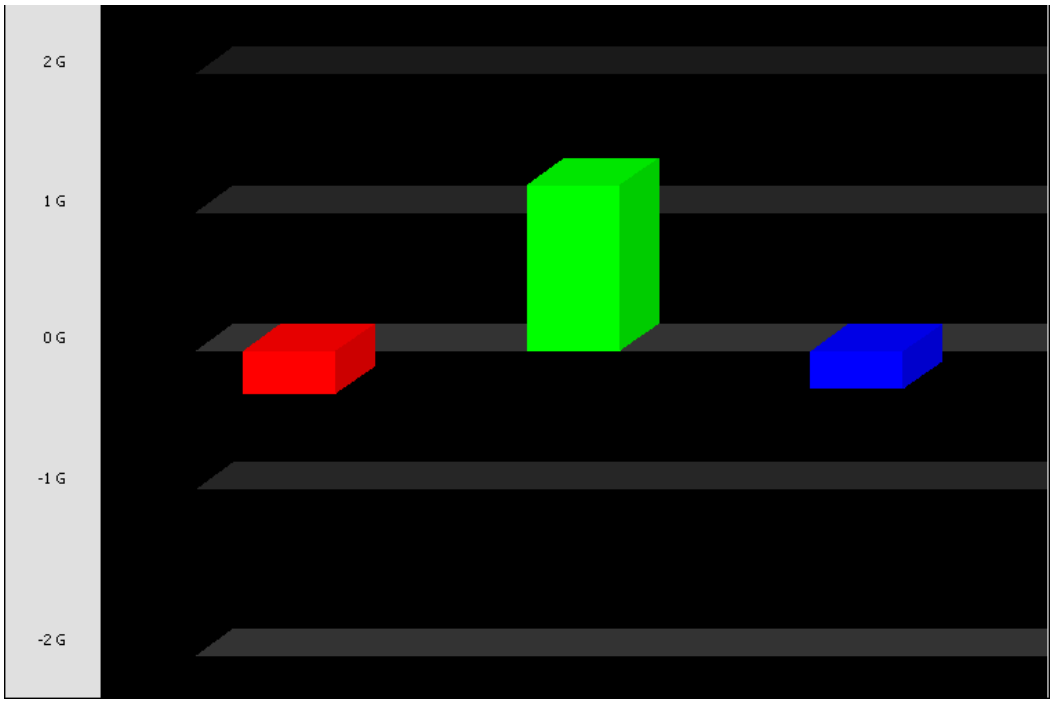


## 3.4 “Bars” tab

The Bars tab (*Figure 12*) displays the acceleration data measured by the LIS302DL sensor in bar chart format. The accelerations along the X, Y and Z axes correspond respectively to the RED, GREEN and BLUE bars.

The length of each bar is determined by the amplitude of the acceleration signal measured along the related axis. The full scale of the graph depends on the FS bit of CTRL_REG1 that may be changed through both the Option (*Figure 10*) and the Register Setup tabs (*Figure 11*).

**Figure 12. Bars tab**

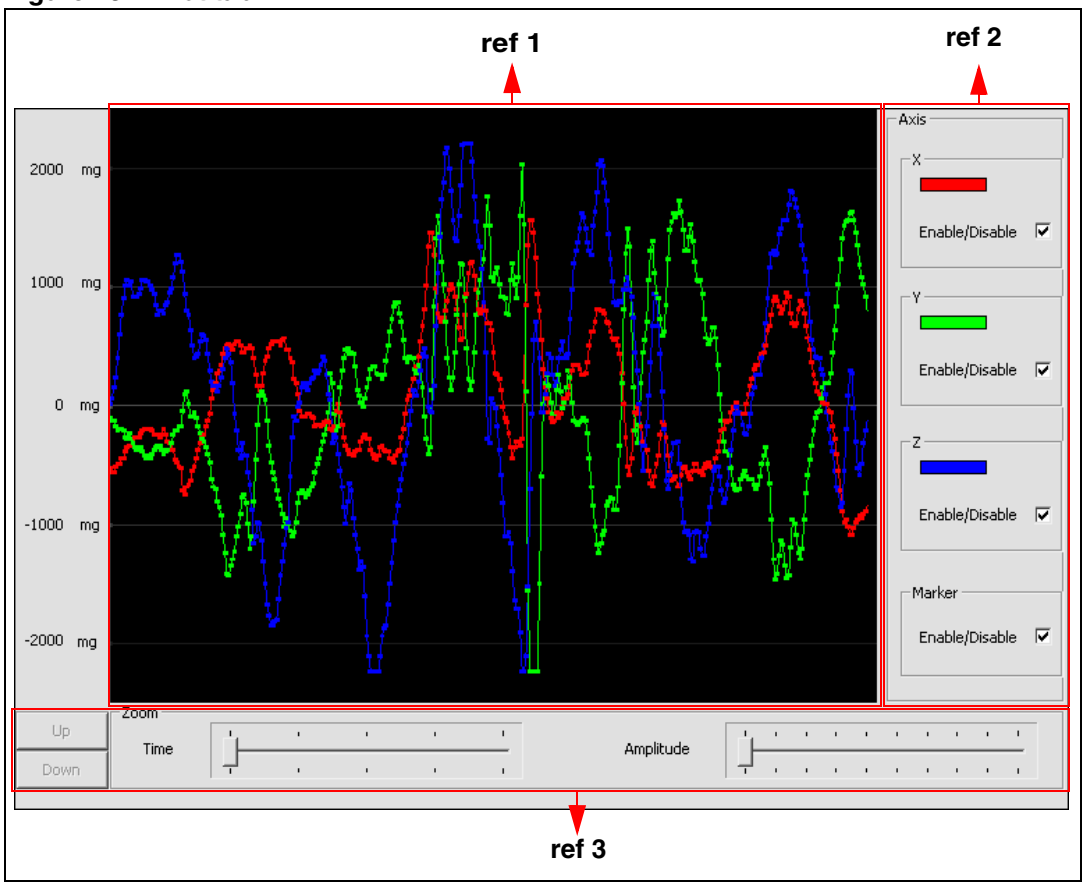


## 3.5 “Plot” tab

The Plot tab (*Figure 13*) is divided into three sections:

- “Main window” (ref 1) - Shows the sequence of acceleration samples that have been measured by the LIS302DL MEMS sensor mounted on the evaluation kit.
- “Visualization options” (ref 2) - Allows the user to enable/disable the trace related to each axis and to show/hide the marker on the plot diagram.
- “Zoom options” (ref 3) - Permits enlargement of the plot in the horizontal (Time) and vertical (Amplitude) directions and to move the center of the plot upward/downward with the “Up” and “Down” buttons.

**Figure 13. Plot tab**



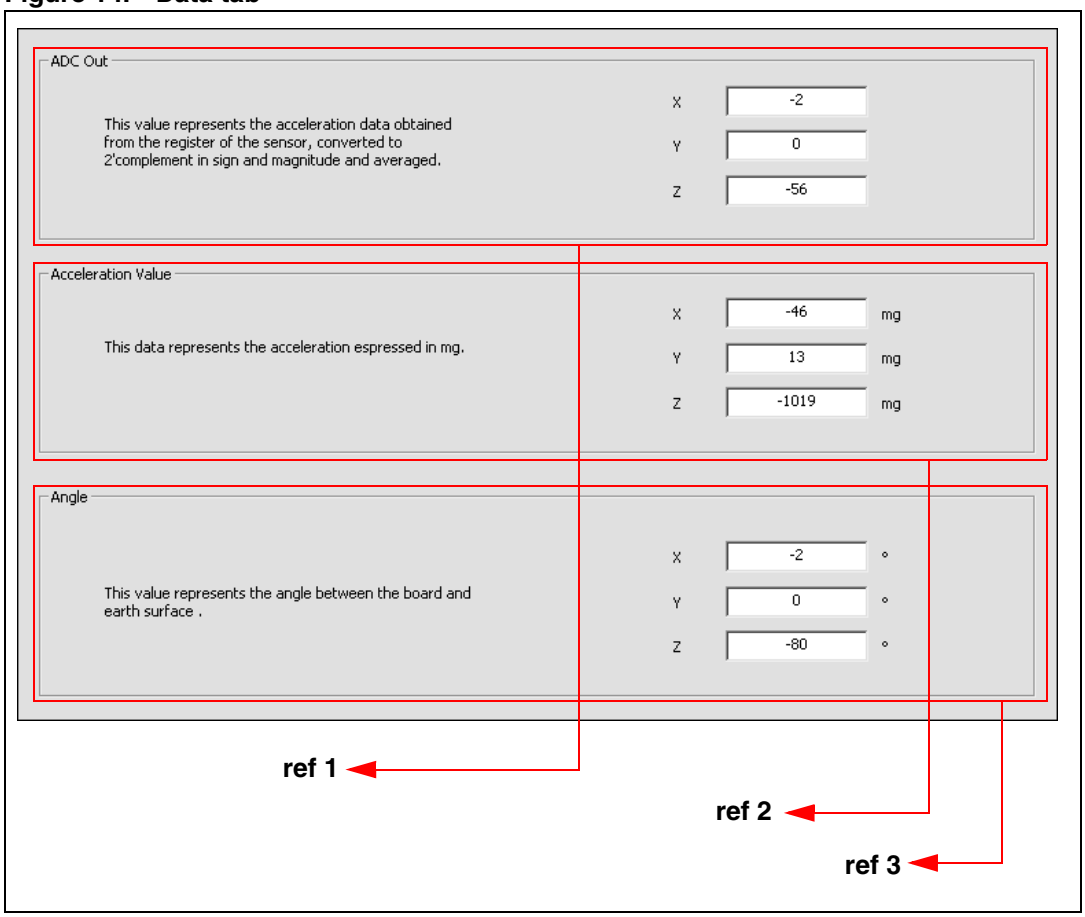
## 3.6 “Data” tab

The Data tab (*Figure 14*) shows the acceleration values measured by LIS302DL sensor. It is divided into three boxes:

- “ADC Out” (ref 1) - Displays the acceleration data provided by the sensor after its conversion from 2’s complement to magnitude and sign.
- “Acceleration Value” - Represents the acceleration data measured by the sensor, expressed in mg.
- “Angle” - Returns the tilt angle, expressed in degrees, that is inferred from the “ADC Out” data.

*Note: To increase data readability, the values shown in the boxes described above are based on an average of 50 samples.*

**Figure 14. Data tab**



## 3.7 “Inclinometer” tab

The Inclinometer tab (*Figure 15*) represents the acceleration data measured by the sensor in the form of an artificial horizon.

**Figure 15. Inclinometer tab**

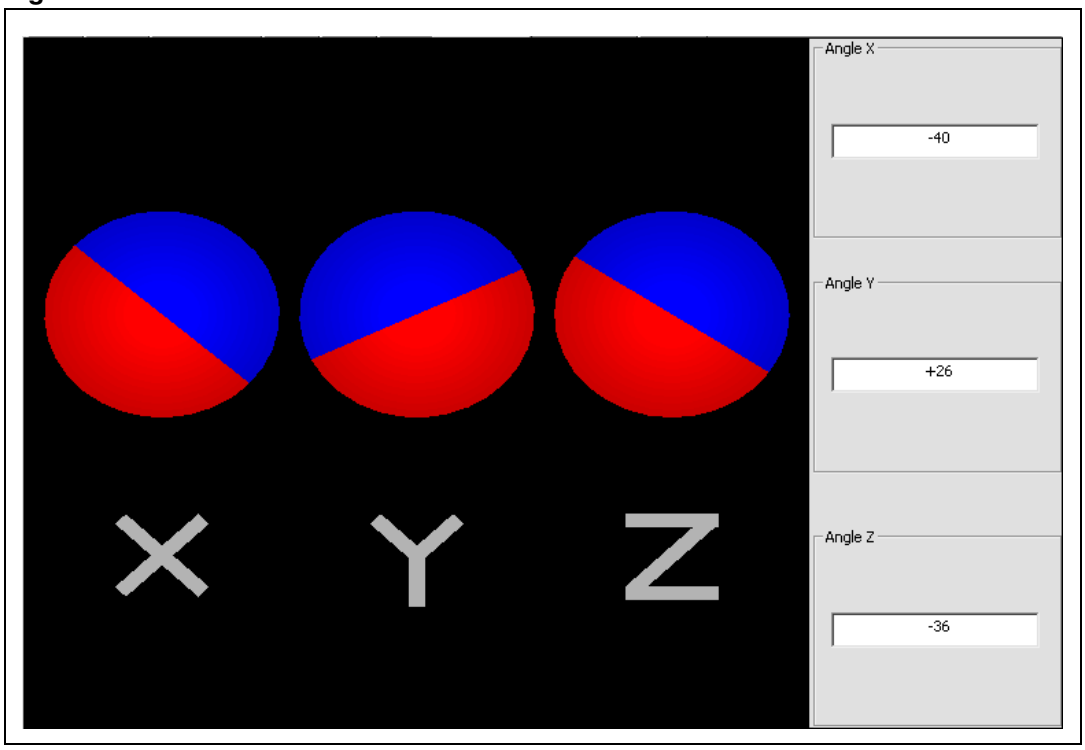
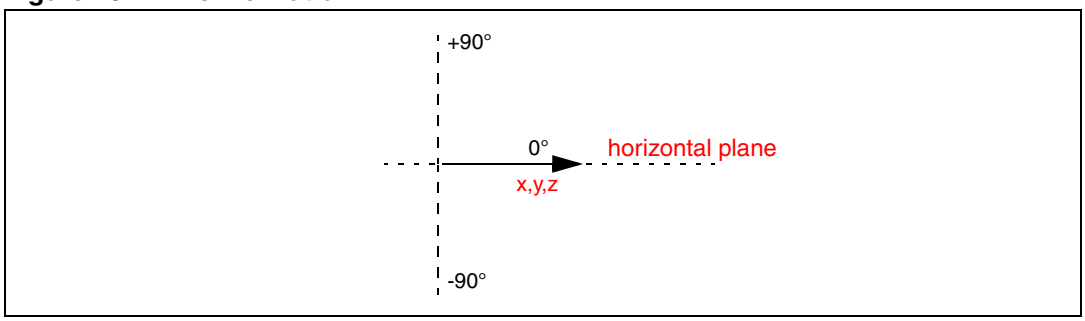


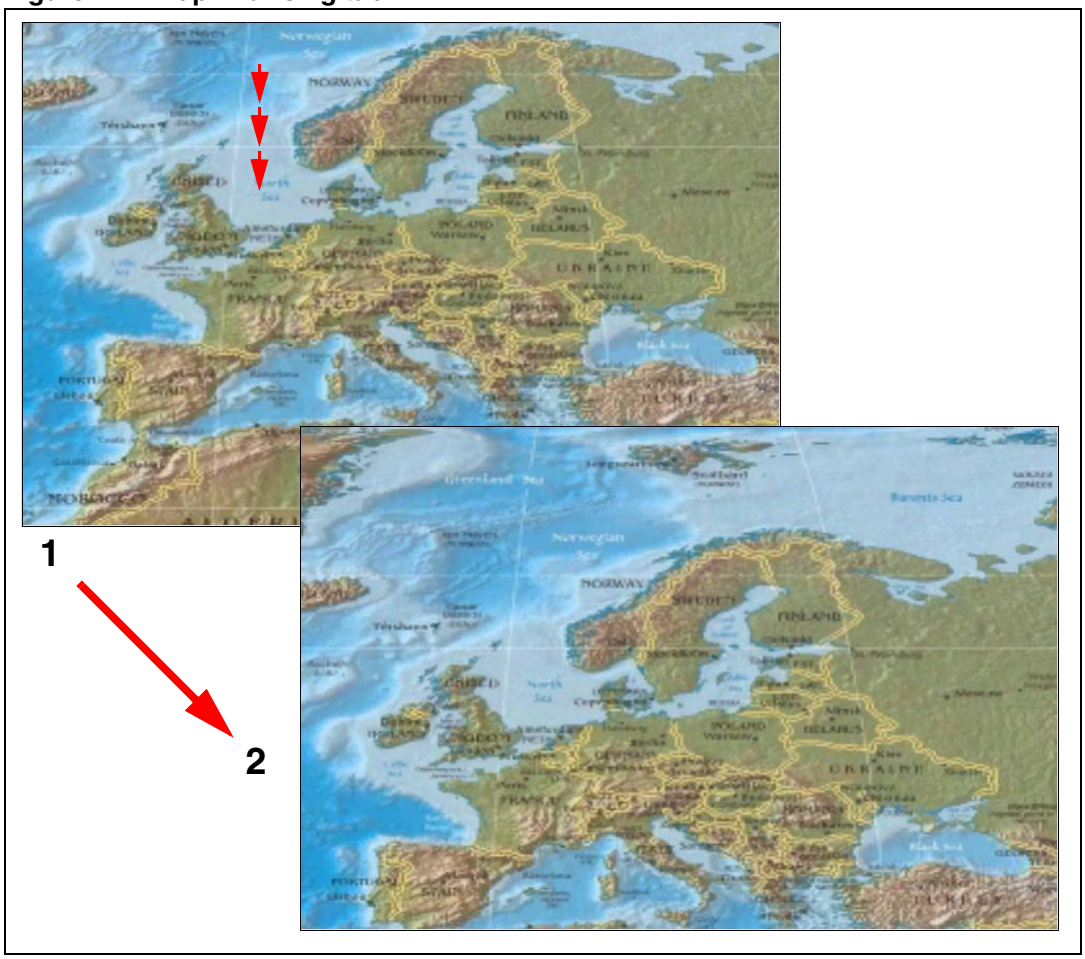

**Figure 16. Axis Inclination**



## 3.8 “Map Browsing” tab

The Map Browsing tab (*Figure 17*) demonstrates the possibility of using the acceleration data obtained from the sensor to scroll a map (or another type of document) on the screen.

**Figure 17. Map Browsing tab**



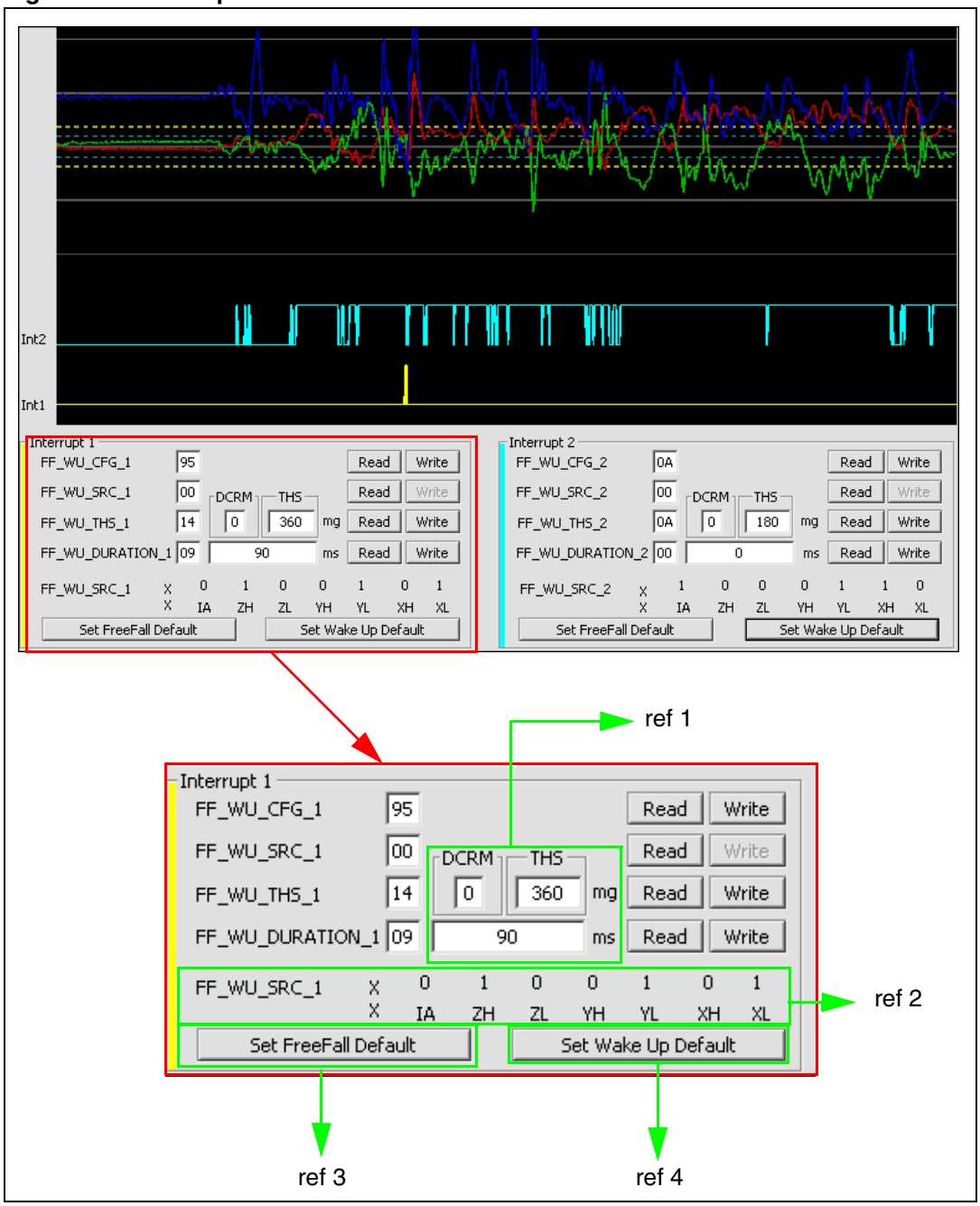

## 3.9 “Interrupt” tab

The Interrupt tab (*Figure 18*) provides a tool for evaluating the interrupt generation features of the LIS302DL MEMS sensor. In this section of the GUI it is possible to configure the characteristics of the inertial events that must be recognized by the device and to visualize, in real-time, the level of the two interrupt lines together with the acceleration signals that are measured by the device.

The GUI provides direct access to the registers (INT_CFG, INT_SRC, THS and DURATION) that allow the configuration of the two independent interrupt sources of the device. Conversion boxes are located on the right most side of the THS and DURATION registers (ref 1). These boxes are intended to show, respectively, the threshold value expressed in mg and the duration value converted in msec for better readability and understanding. On the bottom side of the window (ref 2), the content of the FF_WU_SRC register is reported for an immediate check of its content.

Finally, two buttons are provided for each interrupt line to set the suggested default values for free-fall and wake-up detection. Those buttons are marked “Set FreeFall Default” (ref 3) and “Set Wake Up Default”, respectively (ref 4).

**Figure 18. Interrupt tab**



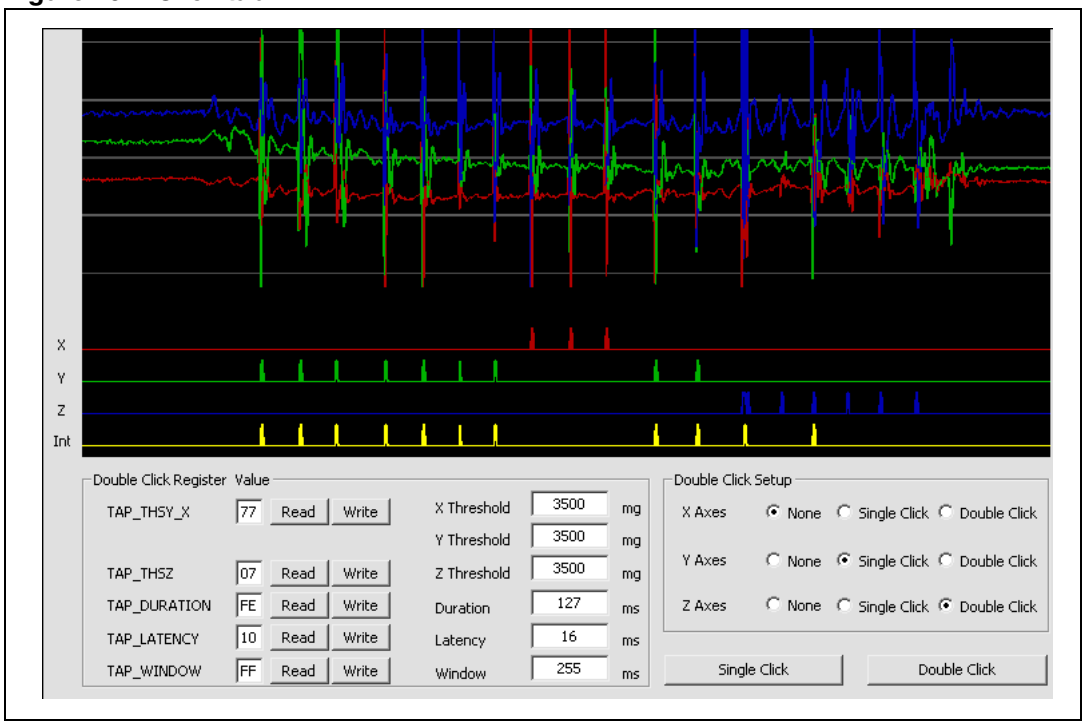
## 3.10 “Click” tab

The Click tab (*Figure 19*) is a tool to evaluate the “Click Recognition” function of the LIS302DL MEMS sensor. This function allows the recognition of a “Single Click” and a “Double Click” event and provides an interrupt when the event occurs.

Acceleration data (top section) and recognized click events (bottom section) are plotted in real-time for each axis. On the bottom the level of the Interrupt is plotted . This tab provides direct access to the registers (TAP_THSY_X, TAP_THSZ, TAP_DURATION, TAP_LATENCY, TAP_WINDOW), allowing the user to fully configure the “Click Recognition” function and the external interrupt lines.

Two buttons allow the user to set standard values for single and double click.

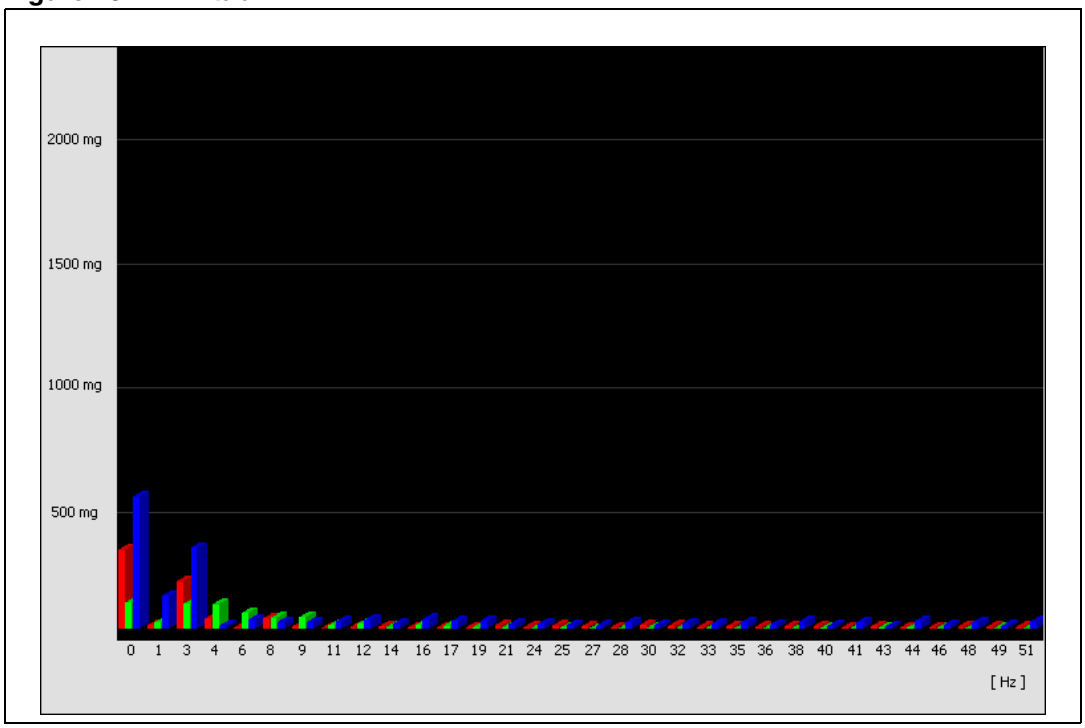
**Figure 19. Click tab**



## 3.11 “FFT” tab

The FFT tab (*Figure 20*) shows the FFT of the acceleration signals acquired by the sensor. The spectral data are updated every sample and are calculated on a 64-sample moving window.

**Figure 20. FFT tab**




# 4 Data acquisition quick start

This section describes the basic steps that must be performed to acquire the acceleration data from the EK302DL:

1. connect the EK302DL to the USB port;
2. start the EK302DL GUI;
3. select the Virtual COM port and click on the “Connect” button (*Figure 9*, ref 1);
4. select the destination file to which the acceleration data must be saved by clicking “Browse” (*Figure 9*, ref 2) in Save section (optional);
5. use the Tab Menu to display the desired function (optional);
6. click on the “Start” button to activate the sensor data collection and screen plotting functions;
7. click on the “Start saving” button to activate the sensor data saving to file;
8. click on the “Stop saving” button to stop the sensor data saving;

9. click on the ”Stop” button to stop the sensor data collection and screen plotting functions;
10. to close the application, click on “Disconnect” and then click on “Exit”.

# 5 EK Lite

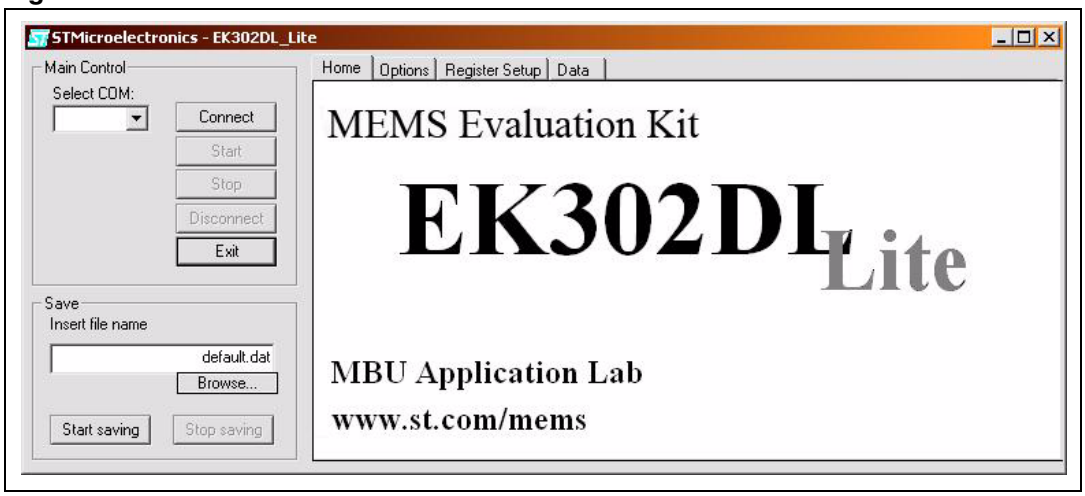
The mini CD included with the EK302DL also contains a lite version of the previous GUI together with its source code. The source code can be found in the directory: ($Home)\STM\EK302DL\EK302DL_lite, where ($Home) is the directory in which the software that came with the evaluation kit was installed (C:\Program Files by default).

The purpose of the lite version is to provide the user a base for the development of a customized application.

The lite version of the evaluation kit is started by launching the EK302DL Lite executable file located in the EK302DL > Executables folder.

An example of the GUI of the EK lite application is shown in *Figure 21*.

**Figure 21. EK302DL Lite GUI**




Follow these instructions to use the software:

1. connect the EK302DL to the USB port;
2. start the EK302DL Lite GUI;
3. select the Virtual COM port and click on the “Connect” button (*Figure 9*, ref 1);
4. select the destination file to which the acceleration data must be saved by clicking “Browse” (*Figure 9*, ref 2) in Save section (optional);
5. use the Tab Menu to display the desired function (optional);
6. click on the “Start” button to activate the sensor data collection and screen plotting functions;

7. click on the “Start saving” button to activate the sensor data saving to file;
8. click on the “Stop saving” button to stop the sensor data saving;
9. click on the ”Stop” button to stop the sensor data collection and screen plotting functions;
10. to close the application, click on “Disconnect” and then click on “Exit”

The GUI also gives read/write access to the registers embedded in the LIS302DL device and allows a single read of the acceleration data measured by sensor.

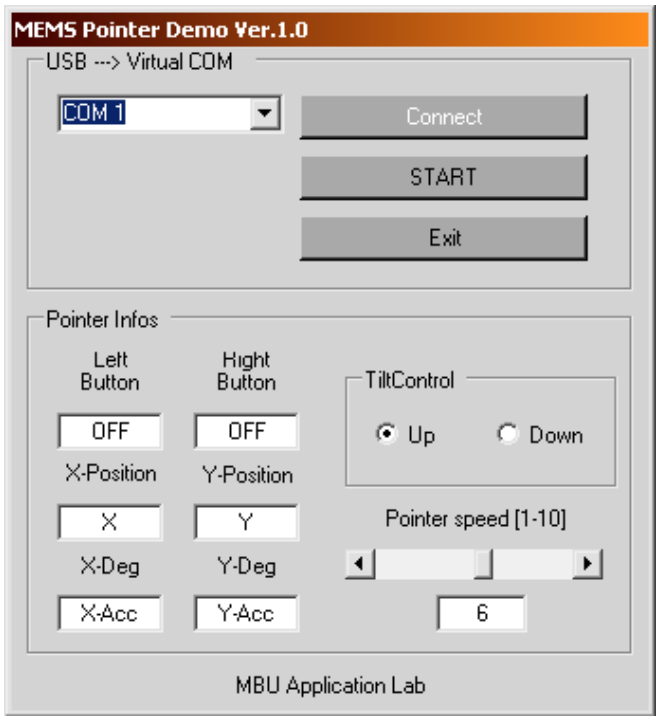
# 6 MEMS pointer

This section describes how to use a simple pointer application, which utilizes acceleration data provided by the LIS302DL MEMS 3-axis linear accelerometer to control the position of a pointer on the screen of the PC. The software provided with the kit allows the EK302DL Evaluation Kit board to be used as an inertial mouse, where the tilt of the board is translated into movement of the pointer. The board also emulates the left and right buttons of the mouse.

## 6.1 GUI description

The GUI window (see *Figure 22*) is divided into two sections. The top section contains the main controls to open the connection to the evaluation kit and to start/stop the data acquisition. The bottom section contains the pointer application controls.

**Figure 22. MEMS Pointer Demo**



### 6.1.1 Right side: main controls

The buttons on the right side of the GUI and their related functions are described below:

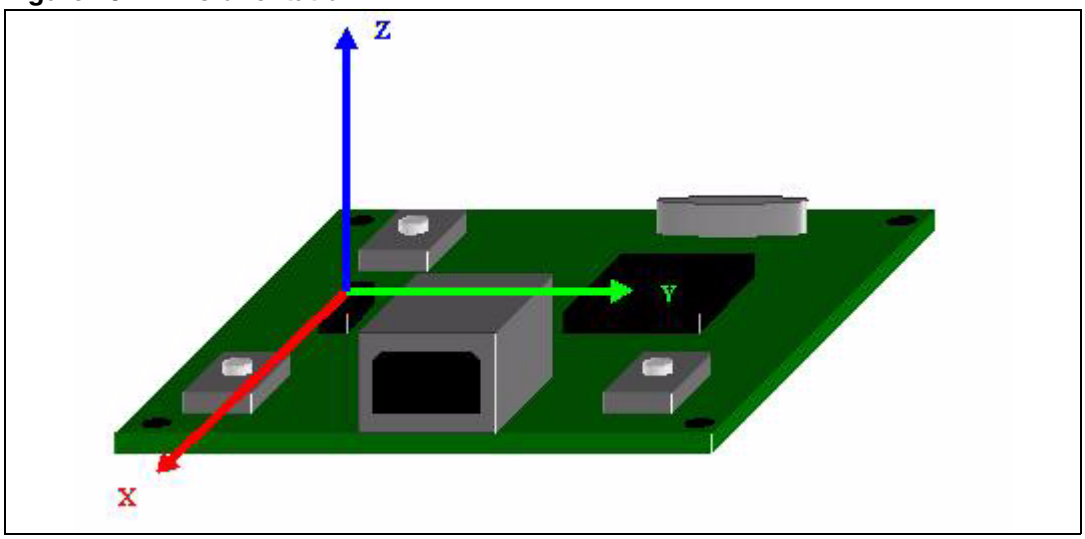
- Connection control - Selects the COM port on which the EK board is connected.
- Acquisition control - Starts and stops acquisition.
- Exit - Exits the MEMS Pointer Demo application.

### 6.1.2 Left side: pointer application controls

The controls on the left side of the GUI and their related functions are as follows:

- Left button/right buttons - Indicates when the left/right button on the evaluation kit is pressed.
- X/Y-position - Shows the current x/y coordinates of the mouse pointer on the PC screen.
- X/Y-deg - Shows the tilt of the evaluation kit along the X and Y axes as depicted in *Figure 23*.
- Tilt control - Allows the user to select the direction of the vertical displacement on the screen vs. the direction in which the board is tilted. For example, by selecting “Up” the pointer will move upward when the evaluation kit is tilted forward. Conversely, by selecting “Down” the pointer will move downwards when the board is tilted backward.
- Pointer speed - Sets the sensitivity of the pointer to the inclination of the board.

**Figure 23. Axis orientation**



# 7 Supported commands

The microcontroller mounted on the EK302DL board is equipped with dedicated firmware which supports a set of commands that allow the control of the 3-axis digital output MEMS sensor and permit the aquisition of the measured acceleration data. The firmware also handles the communication between the EK board and the PC through the USB bus. These features allow users to easily write their own applications to exploit the capabilities of the accelerometer.

This section describes the commands that are supported by the firmware loaded in the microcontroller of the EK302DL Evaluation Kit.

## 7.1 Getting started

Before using the commands supported by the firmware, the following procedure must be performed:

1. connect the EK302DL to the USB port;
2. launch an application which allows the sending of commands through the Virtual serial port. The remainder of this document will assume the use of the Microsoft© Hyper Terminal program integrated in the Windows XP operating system;
3. create a new connection, enter a name (ex. “EK302DL”), and click “OK”;
4. in the “Connect Using” field, select the Virtual COM port to which the USB port has been mapped, and click “OK”;
5. in Port Settings, set Bits per second to 115200, Data bits to 8, Parity to None, Stop bits to 1, and Flow control to None. Click “OK”;
6. in the Hyper Terminal select Files > Properties > Settings and then click on the “ASCII Setup” button;
7. select “Send line ends with line feeds” and “Echo typed characters locally”;
8. click the “OK” button to close the “ASCII Setup” window;
9. click the “OK” button to close the “Properties” window.

Once this procedure has been completed the user can utilize the commands described in the following sections by typing them into the Hyper Terminal window.

## 7.2 Supported commands

The table below lists the commands supported by the EK302DL firmware:

**Table 1. Supported commands**

| Command | Description | Returned value |
|---|---|---|
| *start | Starts continuous data acquisition | S T x y z I1 I2 s |
| *debug | Returns the acceleration data in readable text format | x=XX y=YY z=ZZ |
| *stop | Stops data acquisition | |
| *rAA | Register read | RAAhDDh |
| *wAADD | Register write | |
| *bwAA<0:7><0l1> | Single bit write | |
| *Zon | Force 3-state | |
| *Zoff | Exit from 3-state | |
| *dev | Device name | LIS302DL |
| *ver | Firmware version | 302DL 1.1 |

*Note: AA: register address*

*DD: data*

*S: service field*

*XX, YY, ZZ: Acceleration data returned for the X, Y and Z axes*

*I1, I2 : interrupt value on each axes.*

### 7.2.1 Start command

The *start command initiates the continuous data acquisition. When this command is sent to the board, it returns the acceleration data measured by the LIS302DL device. The acceleration data are packed in a string composed of eight bytes: "*s t X Y Z I1 I2 SD*". The first two bytes are always *"s"* and *"t"* which correspond to the hexadecimal values {73 74}, while "*X*" "*Y*" "*Z*" represent, respectively, the acceleration data for the X, Y, Z axes.

*"I1"* and *"I2"* contain the values of FF_WU_SRC1 and FF_WU_SRC2, where each bit is a specific interrupt.

The last byte *"s"* returns information about the switches mounted on the board. Specifically, bit#1 and bit#0 of the "service data" correspond to the status of SW3 and SW2 on the evaluation kit board, and they are set to 1 when the corresponding switch is pressed.

### 7.2.2 Debug command

The *debug command starts the continuous data acquisition in debug mode. When this command is sent to the board it returns the acceleration data measured by the LIS302DL device in readable text format. The values shown on the screen correspond to the content of the output data registers and are shown as a hexadecimal number. A TAB is employed as a separator between the different fields.

### 7.2.3 Stop command

The *stop command interrupts any acquisition session that has been started with either the *start or *debug commands.

### 7.2.4 Register read

The *rAA command allows the contents of the LIS302DL device registers in the evaluation kit board to be read. AA, expressed as hexadecimal value and written in upper-case, represents the address of the register to be read.

Once the read command is issued, the board will return RAAhDDh, where AA is the address sent by the user and DD is the data present in the register.

For example, to read the CTRL_REG1 the user would issue the command *r20, which returns R20hC7h.

### 7.2.5 Register write

The *wAADD command permits writing to the contents of the LIS302DL device registers in the evaluation kit board. AA and DD, expressed as hexadecimal values and written in upper-case, represent respectively the address of the register and the data to be written. To write 0xC7 to the CTRL_REG1, for example, the user would issue the command *w20C7.

### 7.2.6 Single bit write

Using this command it is possible to set/reset a single bit in a given register. The command *bwAA<0:7><0|1> requires the user to specify the address AA of the register in which to change the bit, with AA expressed as a hexadecimal value and written in lower-case, followed by the position of the bit to be changed, an integer between 0 and 7, and the value, either 0 or 1, to be associated to the specified bit.

For example, to set to 1 the FS bit within the CTRL_REG2, the user would issue the command *bw2171.

### 7.2.7 Zon and Zoff

The *Zon and *Zoff commands are employed respectively to put into 3-state (i.e. high-impedance) and to exit (i.e. normal mode) the SPI lines of the ST7-USB microcontroller mounted on the evaluation kit. These commands allow the isolation of the sensor from the microprocessor in the event that an external control (from a different microcontroller mounted on a separate board) is needed.

By default, when the kit is first turned on, the SPI lines are in 3-state mode and the user is required to send the command *Zoff to allow the communication between the sensor and the microcontroller.

### 7.2.8 Device name

The *dev command retrieves the name of the device mounted on the evaluation kit connected to the PC. For the EK302DL, the returned value is *“LIS302DL”*.

### 7.2.9 Firmware version

The *ver command queries the evaluation kit and returns the version of the firmware loaded in the microprocessor.

## 7.3 Quick start

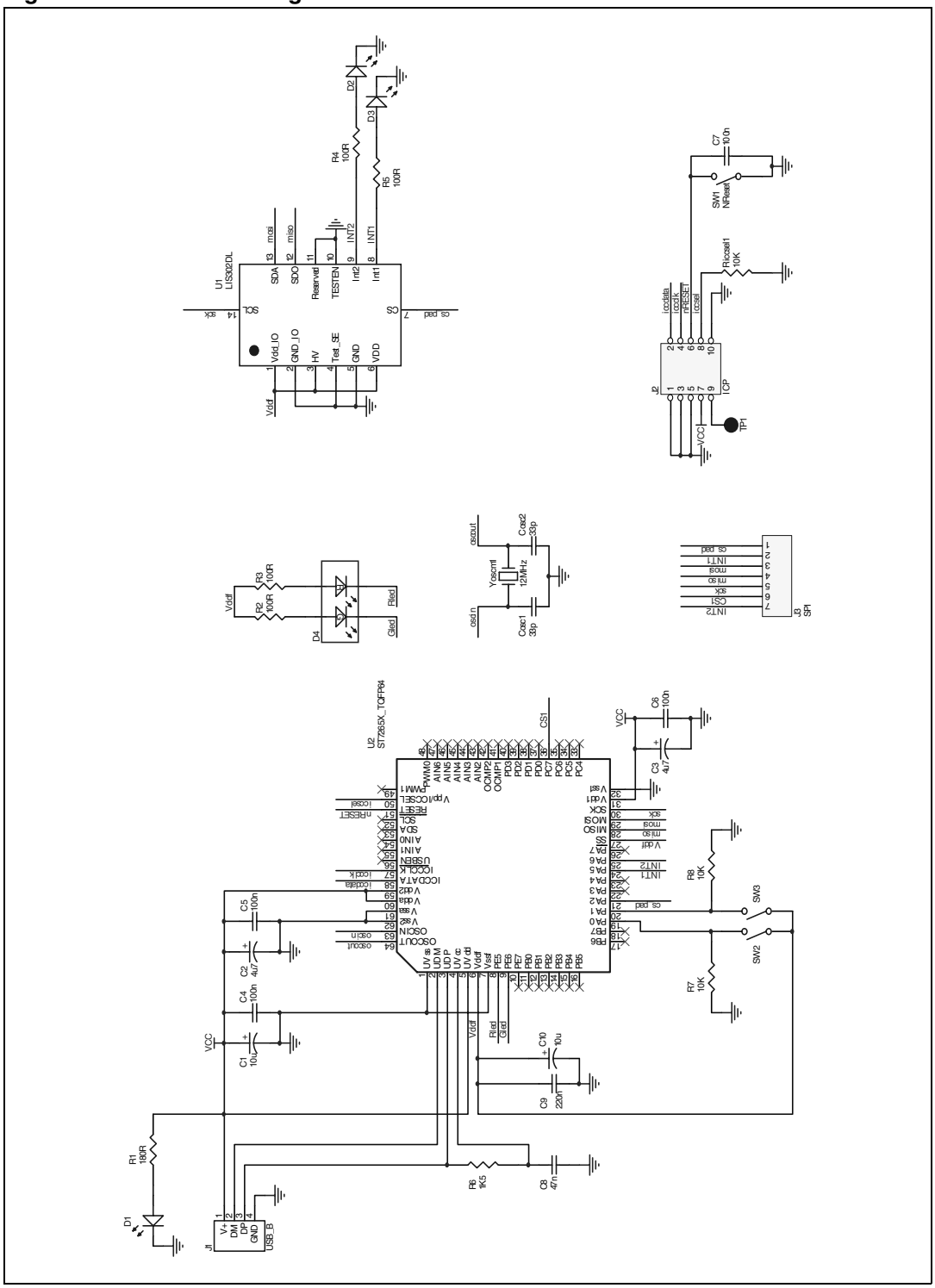
This section shows the basic sequence of commands to start a data communication session and retrieve the acceleration data from the evaluation kit:

1. connect the EK302DL to the USB port;
2. start Microsoft© Hyper Terminal and configure it as described in section *7.1*;
3. inside the Hyper Terminal window, enter the command *Zoff to enable the control of the SPI line from the ST7-USB microcontroller;
4. send the *debug command to get the acceleration data measured from the sensor;
5. send *stop to end the continuous acquisition and visualization.

# 8 Schematic diagram

The schematic diagram of the EK302DL Evaluation Kit is shown in *Figure 24*.

**Figure 24. Schematic diagram of the EK302DL board**



# 9 Bill of materials

The bill of materials for the EK302DL Evaluation Kit is provided in *Table 2*.

**Table 2. Bill of materials**

| Designator | Description | Comment | Footprint |
|---|---|---|---|
| C1 | Capacitor | 10 µF | C1206_POL |
| C2 | Capacitor | 4.7 µF | C1206_POL |
| C3 | Capacitor | 4.7 µF | C1206_POL |
| C4 | Capacitor | 100 nF | 0805 |
| C5 | Capacitor | 100 nF | 0805 |
| C6 | Capacitor | 100 nF | 0805 |
| C7 | Capacitor | 100 nF | 0805 |
| C8 | Capacitor | 47 nF | 0805 |
| C9 | Capacitor | 220 nF | 0805 |
| C10 | Capacitor | 10 µF | C1206_POL |
| Cosc1 | Capacitor | 33 pF | 0805 |
| Cosc2 | Capacitor | 33 pF | 0805 |
| D1 | Led | SMD_LED red | SMD_LED |
| D2 | Led | SMD_LED red | SMD_LED |
| D3 | Led | SMD_LED green | SMD_LED |
| D4 | Led | | SMD_LED_3C |
| J1 | USB connector | USB_B | USB_B |
| J2 | Header, 5X2 | ICP | HEADER_5X2_A |
| J3 | Header, 7-Pin | SPI | HDR1X7 |
| R1 | Resistor | 180 Ω | 0805 |
| R2 | Resistor | 100 Ω | 0805 |
| R3 | Resistor | 100 Ω | 0805 |
| R4 | Resistor | 100 Ω | 0805 |
| R5 | Resistor | 100 Ω | 0805 |
| R6 | Resistor | 1.5 kΩ | 0805 |
| R7 | Resistor | 10 kΩ | 0805 |
| R8 | Resistor | 10 kΩ | 0805 |
| Riccsel1 | Resistor | 10 kΩ | 0805 |
| SW1 | Button | NReset | SMT_Button |
| SW2 | Button | SMT_Button | SMT_Button |
| SW3 | Button | SMT_Button | SMT_Button |
| U1 | | LIS302DL | TLGA_5x3x1 |
| U2 | | ST72F651AR6T1E | TQFP64_10x10 |
| Yoscm1 | Crystal | 12 MHz | OSC_SMD |

# 10 Revision history

Table 3. Revision history

| Date | Revision | Changes |
|---|---|---|
| 24-Nov-2006 | 1 | Initial release. |
| 08-Jun-2007 | 2 | Click Tab description added. |

**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 - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

**www.st.com**