SOREXSENSORS

Sensing a better future

User's Manual

SFSDEVKIT

V 3- December 2020

www.sorexsensors.com

SFSDEVKIT is in engineering release. Sorex Sensors cannot guarantee performance of the system and software.

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1. Description of the Kit.

1.1. Content

The Sorex Sensors Evaluation Kit consists of the following parts:

1) One sensor (or more, depending on the purchase) individually mounted on a T-shaped card (Figure 1).
2) One driving circuit box with two inputs for the sensor cards and a USB output (Figure 2).
3) One USB cable

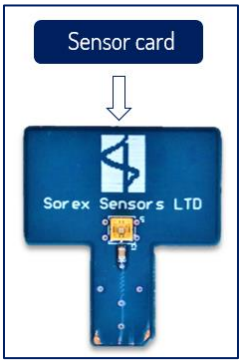


Figure 1: Sorex Sensor mounted on a card.

Figure 2: Driving circuit box with two sensors connected.

BE AWARE THE SENSOR PACKAGE HAS NO LID. THE SENSOR'S DIE IS EXPOSED, AS WELL AS ITS CONNECTING WIRES. THEREFORE, THE SENSORS MUST BE HANDLED WITH CARE TO AVOID BREAKING THE CONNECTIONS.

1.1. Installation of the kit

To install the kit follow these steps.

1. **Unwrap the kit** and identify the sensors and the driving circuit box.
2. **Connect the USB cable to a PC** station where the software will be installed.
3. **Identify the input sockets** in the front of the driving circuit box.
4. **Insert a sensor card** for each socket you would like to use.
5. The kit is now ready to be used.

Once a sensor has ceased working, extract the sensor card and replace it with a new one for a new measurement.

BE AWARE THAT THE SENSOR MOUNTED ON THE CARD HAS ITS CONNECTING WIRES EXPOSED.
IT MUST BE HANDLED WITH CARE TO AVOID BREAKING ANY CONNECTIONS.

1.2. Architecture and Working Principle

The working principle of the kit is explained using the architecture in Figure 3. It is based on a differential measure between the signals generated by the sensing and reference elements, respectively. Each sensor is made to resonate so to produce a stable signal peaked at its own resonance frequency (or frequencies, in case of multiple resonances). The interface board down-converts the signal generated by the sensing element (at frequency: f_{sense}) using the reference as carrier (at frequency: f_{ref}), so that the frequency difference: $\Delta f = f_{ref} - f_{sense}$, is extracted.

Next, Δf is acquired by the microcontroller once the corresponding input of the multiplexer is activated. The microcontroller samples Δf over a few milliseconds (gating time), average them into a single value: $\langle \Delta f \rangle$, which is then sent to the software application for visualization.

The operations just described are cyclical. The user can set the sampling rate via the software interface, so that each measurement is acquired at the desired rate: typically, one sample / second. The interface boards are multiplexed, namely the sensor on each board is polled alternatively at every cycle.

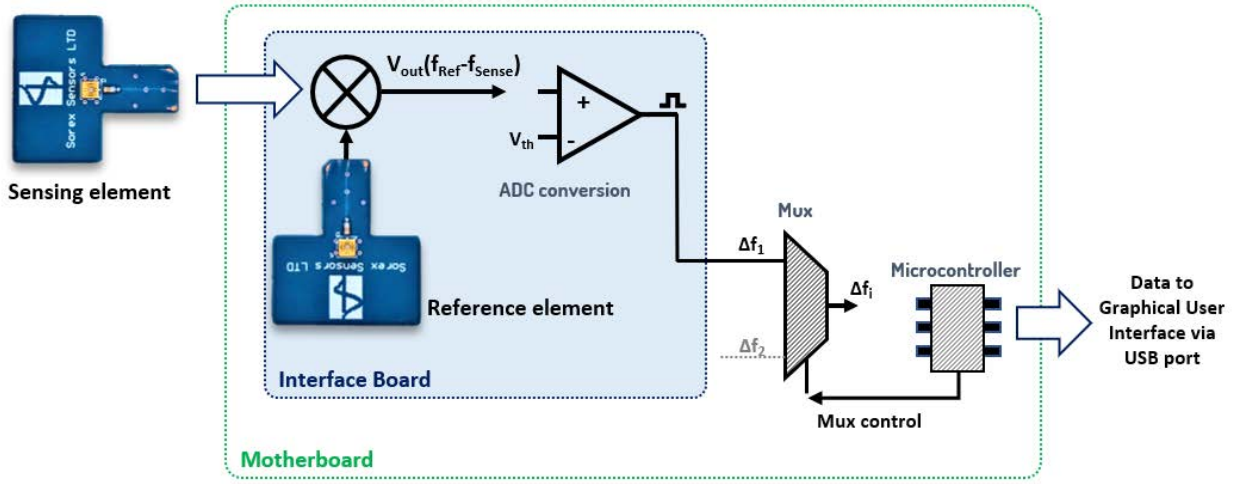


Figure 3: Architecture of the Evaluation Kit.

The measured signal <Δf>, is thus an average measurement of the difference in the resonant frequency of the sensing and reference elements, respectively. Variations in <Δf> arise from changes in the mass deposited over the active area of the sensor or due to a temperature variation. Since the reference is located inside the driving circuit box, it is masked from the attachment of mass deposited, for instance, using line-of-sight deposition systems, like an evaporator or a sputtering tool. Besides, it is maintained in thermal equilibrium with the surrounding electronics.

The sensing element, instead, is easily accessible. It's sensing area can thus be targeted for the deposition of materials (insulators), for chemical functionalization, or for applying a temperature variation. In all these cases, the measured signal <Δf> will be proportional to the change in the resonant frequency of the sensing element only, thus providing sensing.

2. Software Installation

2.1. File installation

The software consists of a single application (.exe file) with a few configuration files. It is advised to create a dedicated folder in the hard drive of the PC executing the application.

1. **Copy all the files** into a dedicated folder in the hard drive of the PC executing the application;
2. Run the application by double **clicking the .exe file**.

ATTENTION: THE SOFTWARE OF THE EVALUATION KIT HAS BEEN TESTED ON A WINDOWS 10 ™ SYSTEM. COMPATIBILITY WITH OTHER OPERATING SYSTEMS IS NOT GUARANTEED.

2.2. Measurement mode.

The application starts with the graphic interface set in 'measurement mode'. The main window will appear on the screen like in Figure 4:

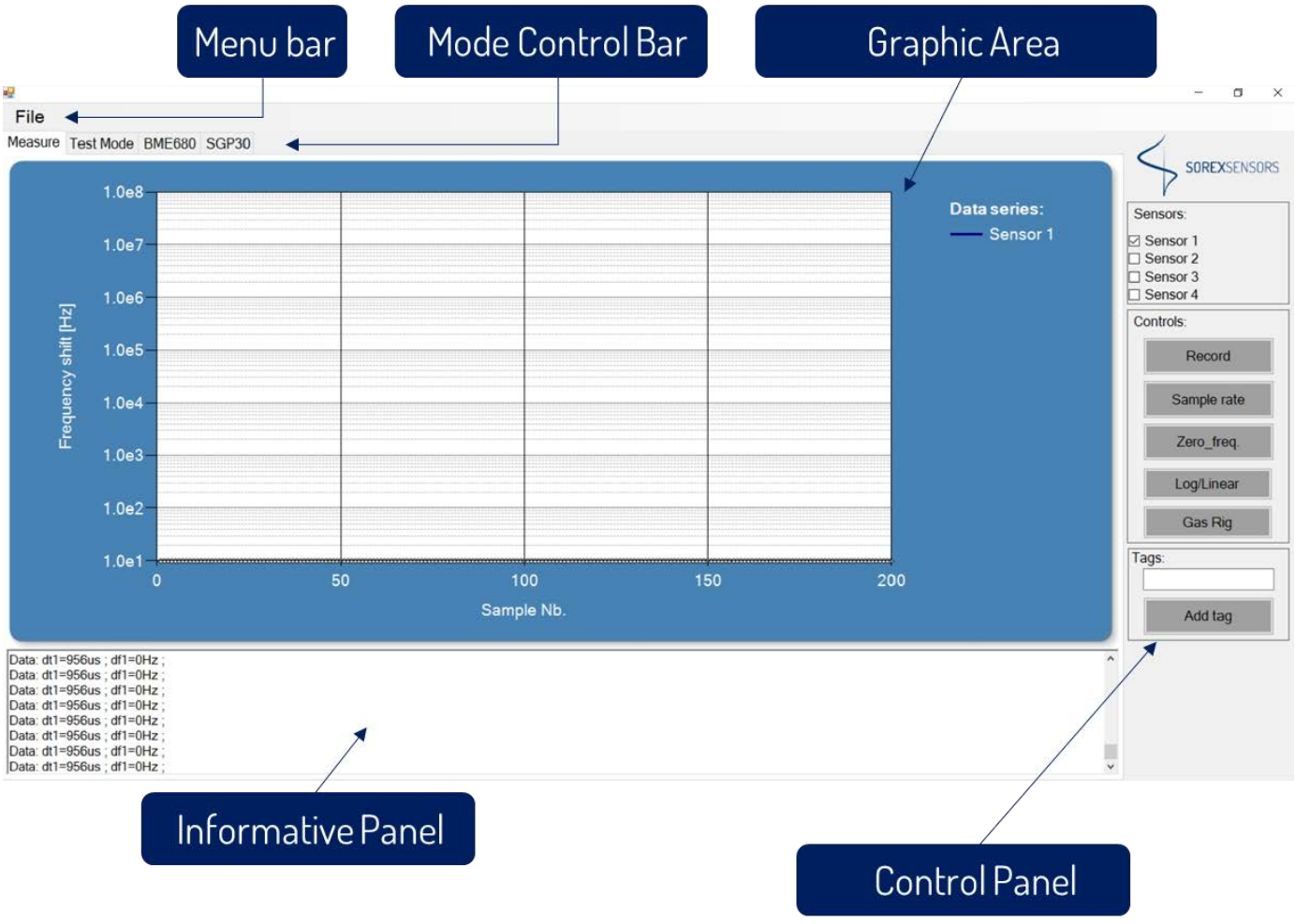


Figure 4: Main window of the software application.

The main window consists of the following areas:

1) A **menu bar** on the top;
2) A **control tab**, also on the top;
3) A **graphic area** reporting the sensor's outputs, in the middle;
4) An **informative textual panel**, at the bottom;
5) A **control panel** with buttons, on the right;

2.2.1. Menu bar

The menu bar contains the classic menu for operations with files. For instance, the user can there find a 'File' tab which allows saving the logged data into a file on the hard drive.

2.2.2. Mode bar

The mode bar allows switching between two different modes:

1. measurement mode;
2. test mode.

By default, the system starts in **measurement mode**. The main window described above is indeed the interface of the measurement mode, through which the user gains access to all the functions to operate the sensor.

The **test-mode** window, on the other hand, contains only functionalities that are needed by the Sorex team for testing and debugging the software, or that are still under development. Some of the commands present in test-mode may have no functionality at all, are still under construction, but may become part of future software releases once validated.

Although the test-mode window may appear of little utility for the user, we prefer not to remove it so to provide the user a perspective of what may become available in future software releases. Feedback from the users would be also highly appreciated.

ALL SOFTWARE FUNCTIONS AVAILABLE TO THE END USER ARE PROVIDED IN THE MEASUREMENT MODE.

2.2.3. Graphic Area

The graphic area of the software reports a graphical reading of the output of the sensors as a function of the sampling rate. The signal represented on the graph is $\langle \Delta f \rangle$, the (averaged) difference between the frequency of the resonance and sensing elements. Variations in $\langle \Delta f \rangle$ arise from the attachment of mass, or temperature differences on one of the sensors, normally the sensing element.

Depending on the number of sensor cards installed, one or more curves may be displayed, each one corresponding to the signal coming from a single interface board. As a visual aid, the LED lights on top of the control panel (below the Sorex logo) will change color accordingly to whether a sensor card is installed or not.

When sensors are left unperturbed, the signal $\langle \Delta f \rangle$ levels off to a plateau whose value represents the difference in resonant frequency of the sensing and reference elements at that point of the

measurement. Although overall flat, the plateau still exhibits fluctuation around its mean value due to noise, which is indeed setting the level of accuracy of the sensor.

2.2.4. Informative Panel

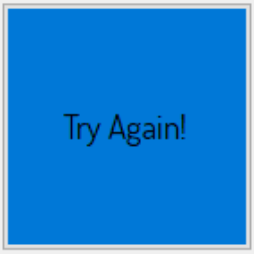
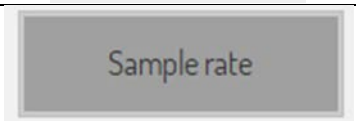
This panel is a textual window showing all the communication between the microcontroller and the software. It is used for diagnostic purposes, as the user can observe in real time the output of the microcontroller while functioning, but also when a diagnostic command is executed.

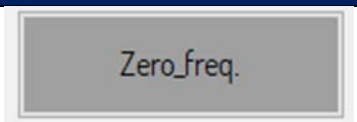
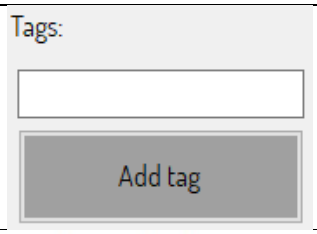
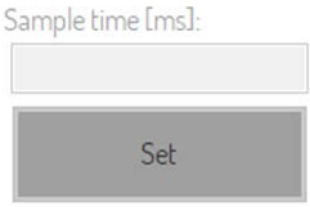
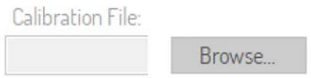
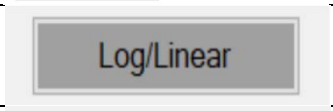
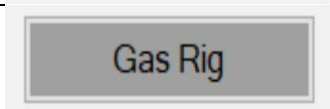
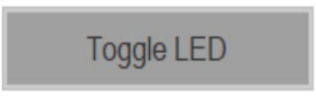
2.2.5. Control Panel

This panel contains all the commands available to the user to control the kit. The control panel includes the logo of Sorex Sensors, and a few LED indicators showing the status of each interface boards.

Depending on the software release, the functions and buttons available may change. In fact, the functionalities eventually shown in the test-mode window will gradually become available to the user in future releases and, once validated, will be transferred on a dedicated button in the control panel.

The functionalities in the control panel are listed below, according to the software release. Functionalities marked as 'under development' may not be available to the user in this current release or may be in the test-mode window.

Software release	Button appearance	Functionality
Beta_2.5		When first executed, it generates a '/LOG' subfolder in the folder of the main application. It then generates a temporary file to store the data coming from each interface boards. By pressing the 'record' button, the user toggles the software from monitoring the data only, to a continuous recording system for storing data safely. Using Save as button the user can gather the data from the log files and export them as a single .csv file.
Beta_2.5		The 'try again' button replaces the record button any time there is a communication error with the microcontroller. Typical examples comprise: a disconnected USB cable or a closed COM port in the operating system. The user should verify the connections and that there are no errors related to the serial ports of the OS. Then click the button for another attempt.
Beta_2.5		Defines the sample rate at which the microcontroller transmits a measurement <Δf> to the software interface. Two sample rates are available to the user: 1. **Fast: 40 [ms]** 2. **Normal: 1 [s]**

Software release	Button appearance	Functionality
Beta_2.5		Zeroes the difference in frequency between the sensing and the reference element. The command shifts all data coming from the microcontroller, so that the sensing and the reference appear as having no difference in resonance frequency. It is useful also to zero the initial discrepancy between sensor and reference, eventually due to process variability.
Beta_2.5		Adds the text present in the blank to the graphic area. It is useful for adding comments to the graphic area, for instance to mark an event. Insert any text in the blank area and click 'add tag' once you'd like it to be attached to the graphic area.
Under development		Available in the test mode tab. Defines the sample rate at which the microcontroller transmits one measurement <Δf> to the user interface. Insert an arbitrary value in the blank area and click set. Value must be in milliseconds. It is recommended to set the value over 300 ms to observe real time changes in the graphic area, faster times will generate some lag in the graph.
Under development		Defines a calibration file to apply to the measured data <Δf>. Click 'browse' to select the calibration file.
Under development		Change the graphic area scale from log to linear.
Under development		Inactive in this version, for use with SFS-GASKIT
Under development		Pauses / restarts measurement.
Under development		Turns the front LED on/off.

3. Making the First Measurement

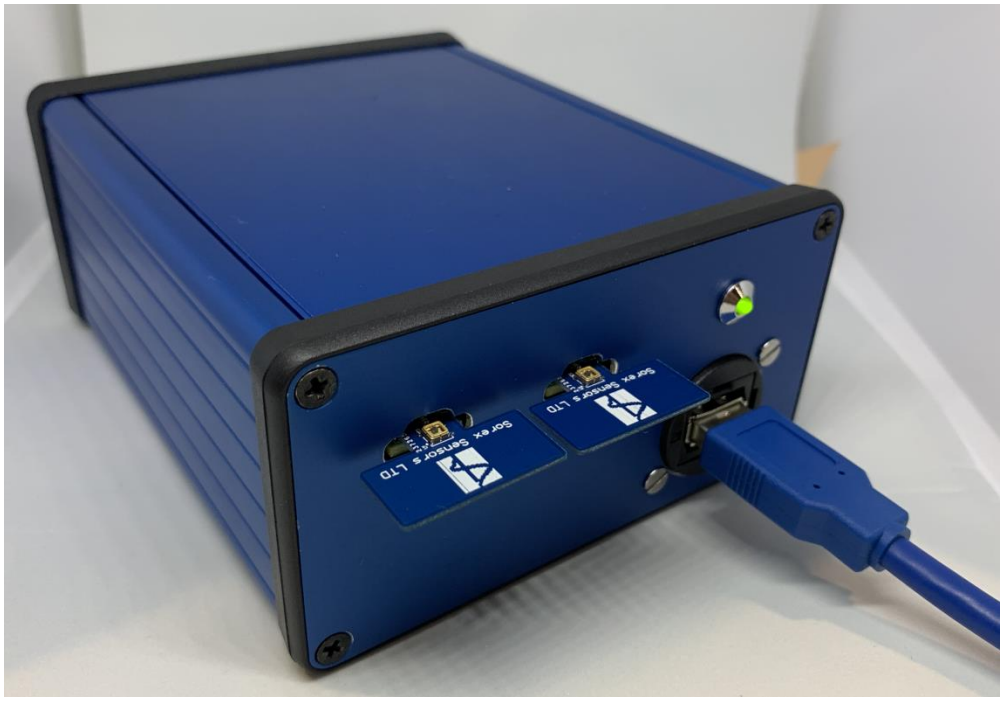


Figure 5: Connection for a first measurement.

1. **Insert the sensor card(s)** in the input socket(s) of the driving circuit box, as shown in Figure 5.
2. **Connect the USB cable to a PC** station.
3. **Launch the software** application.
4. **Click on the Sample_rate button** in the control panel, to set the preferred sampling rate.
5. **Click on the Zero_freq button** in the control panel, to zero the measurements.
6. **Click on the Record button**, to log the data into a file.
7. Perform the desired measurement.
8. **Click on File → Save As…**
9. **Enter the name of the .csv file** you'd like to use to store the measurements.