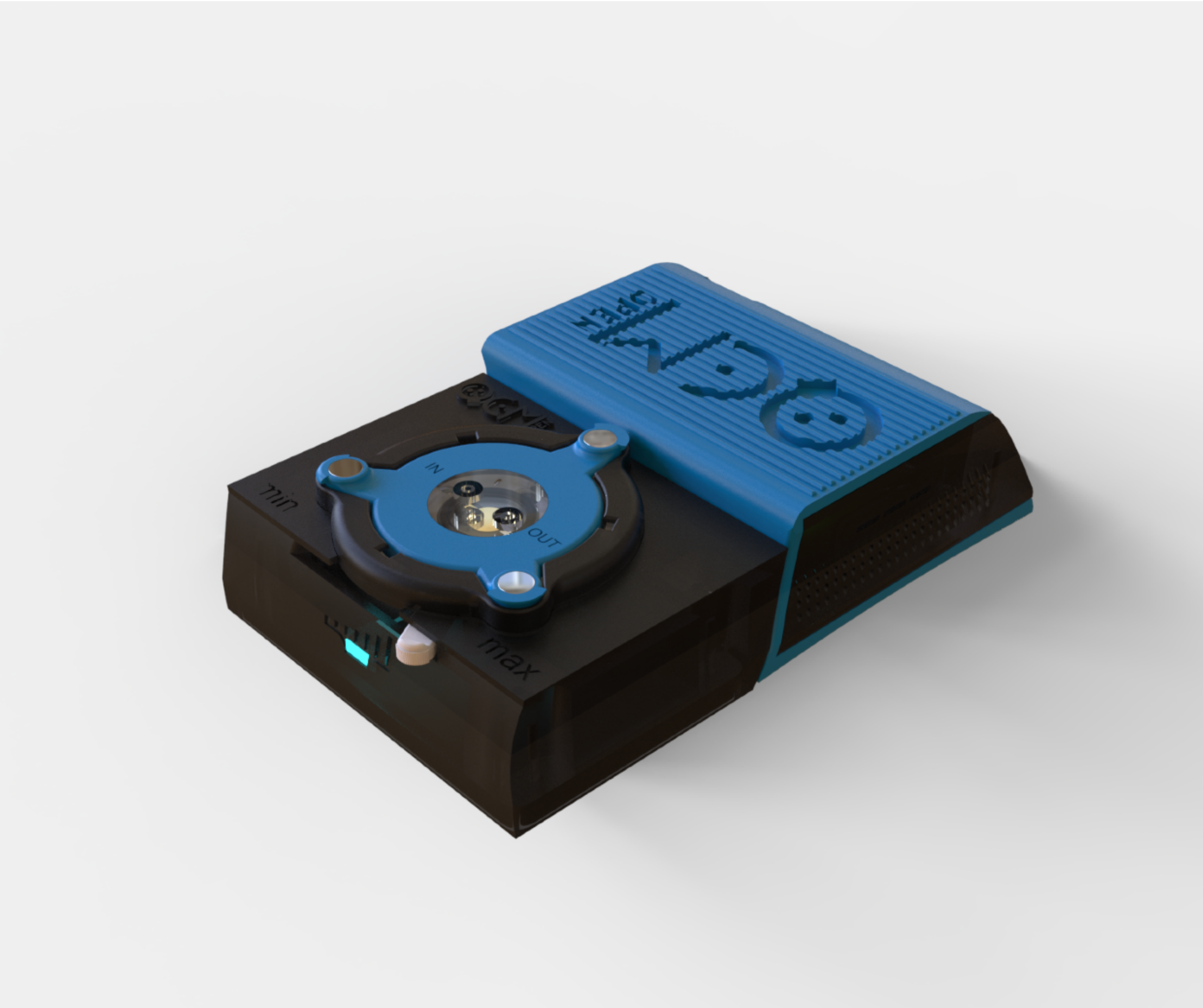

User Manual

OpenQCM Wi2

QUARTZ CRYSTAL MICROBALANCE

openQCM devices are released as scientific open hardware instruments, and they are intended solely for use for SCIENTIFIC, RESEARCH and DEVELOPMENT APPLICATION, DEMONSTRATION, OR EVALUATION PURPOSES and are not considered to be finished end-products fit for general consumer use.

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Date 23 March 2023
Version: 2.0

Why openQCM

Although the openQCM are open source systems, they are proper scientific instruments. We are researchers and we firstly build openQCM for our needs. So, we are firmly convinced that high quality research is not necessarily related to highly expensive proprietary products, characterised by closed-architecture.

GENERAL DESCRIPTION

Sensing Principle

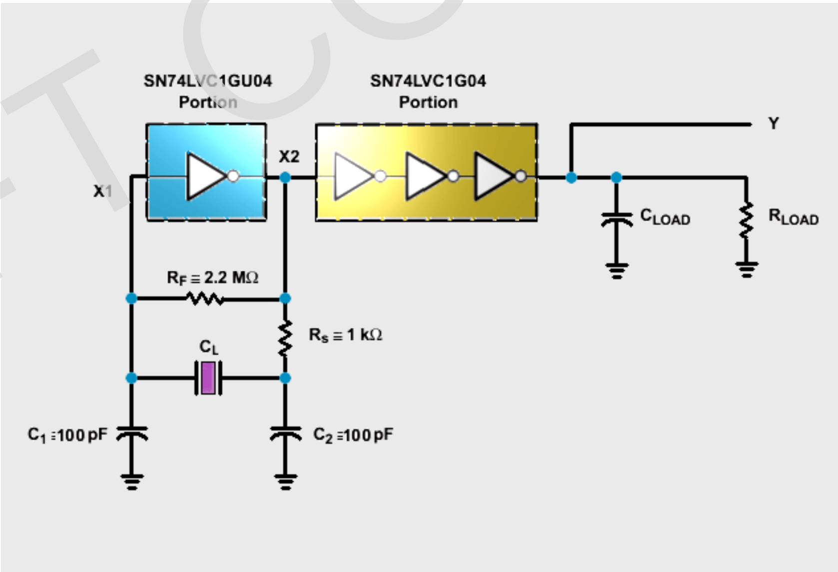
Exploiting the power of simplicity in high accuracy scientific instruments

openQCM Wi2 is the an OSH instrument based on Quartz Crystal Microbalance: a surface sensitive technology capable of measuring phenomena at molecular scale.

openQCM Wi2 is capable of sensing mass variations at nano scale by monitoring in real-time the frequency variations of a piezoelectric quartz crystal sensor. openQCM Wi2 exploits the potentiality and simplicity of Teensy microcontroller, an arduino compatible development board equipped with a 32 bit ARM processor. The electronic circuit is based on a simple and reliable quartz crystal oscillator which automatically tracks the frequency changes. The new openQCM Wi2 electronics is now capable of measuring frequency up to 65 MHz (nominally) openQCM Wi2 is more flexible thanks to its modular design. The main body, which contains the microcontroller and the oscillator circuit, is connected to the external fluidic measuring cell using a standard USB3.0 connector.

HOW FREQUENCY IS MEASURED

The main electronics of openQCM Wi2 is based on a quartz crystal oscillator in Pierce configuration. This kind of electronic oscillator circuit is particularly suitable for applications with piezoelectric quartz crystals. The oscillator circuit is easy to implement, because it uses a minimum number of components, and it shows an exceptional frequency stability giving it an advantage over other oscillator designs. The electronics, based **SN74LVC1GX04**, is designed for creating a crystal oscillator circuit with a buffered square-wave output. According to Pierce's oscillator topology, the first inverter is used as a linear amplifier for crystal oscillator and the last three inverters guarantees a fast edge square-wave at the output.



Teensy 3.2

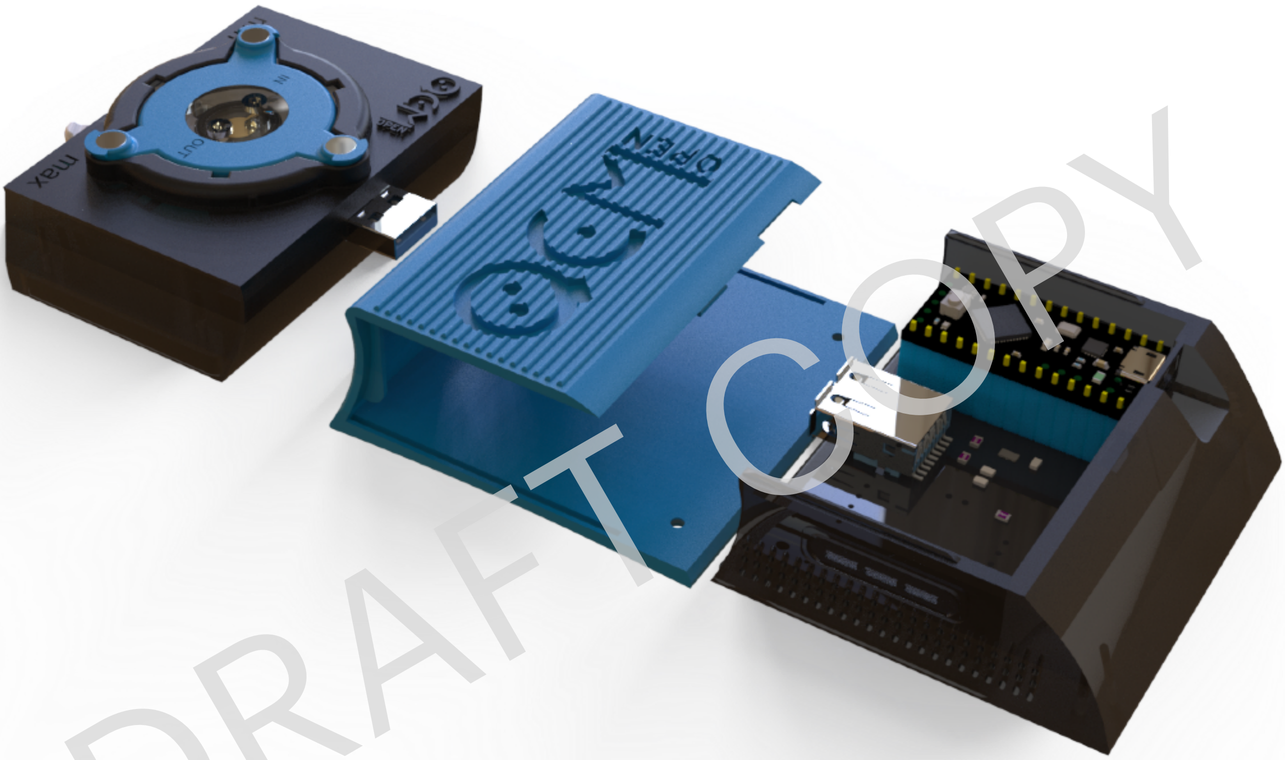
Frequency is measured using the library **FreqCount**, which counts the number of pulses during a fixed time using the microprocessor hardware timer. This procedure works very well at high frequencies, because many cycles can be counted during gate interval. Typical gate time interval is set to 1 second. Teeny 3.2 is capable to measure frequency from 1 kHz up to 65 MHz.

HARDWARE

The Design

More space for your developments

OpenQCM Wi2 has been also designed with modularity in mind. Our idea is based on the assumption that it is much more efficient to have the possibility of using a single fluid module for all devices. The case of the main module is a perfect fitting of the electronics inside it. In addition, space has been provided to accommodate a Wi-Fi module or an extension PCB board that the researcher could design himself.



The new openQCM **sensor module** was born after more than three years of confrontation with the scientific community and is the synthesis of the most important needs we have experienced.

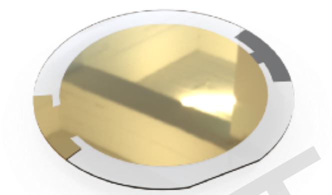
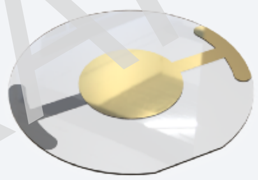
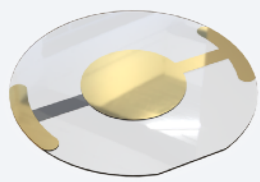
- pogo-pin sensor contacts;
- multi quartz dimension compatibility;
- multi-frequency housing compatibility;
- fine regulation of O-ring; pressure;
- Integrated temperature sensor;
- magnetic back-reaction to sealing.

HOW-TO

QCM Sensors

How to verify the correct side for holding QCM sensors

OpenQCM devices use quartz sensors with wrapped contact electrodes (single side contact). So, it is important to verify the right side you place toward pogo-pins. Below are reported the most representative sensors.

	Top side (sensing side)	Bottom side (to be interfaced to pogo-pins)
Quartz sensor for liquid biosensing		
Standard quartz sensor		

HOW-TO

Setup openQCM Wi2 Sensor Module

Preliminary actions for the correct sensor housing

1.

Remove the top fluidic cover

2.

Place quartz crystal into the sensor module housing, being sure that the electrodes on the back sensor surface are in contact and aligned with the

3.

Insert the top fluidic cover. The fine tuning lever have to be positioned on min, otherwise you will be unable to insert the cover in theirs slots.

4.

Turn the lever

counterclockwise, to ensure the sealing of the sensor module.

HOW-TO

Is everything OK?

How to finely check if the Sensor Module is correctly sealed

Once you inserted the quartz sensor inside the sensor module, it is a good approach to verify if all is in order. So, in order to verify id the fluidic chamber of the sensor module is is correctly sealed, please follow these steps:

- Connect a side of a tube to the **inlet** of the fluidic cover and the other side in a water reservoir.

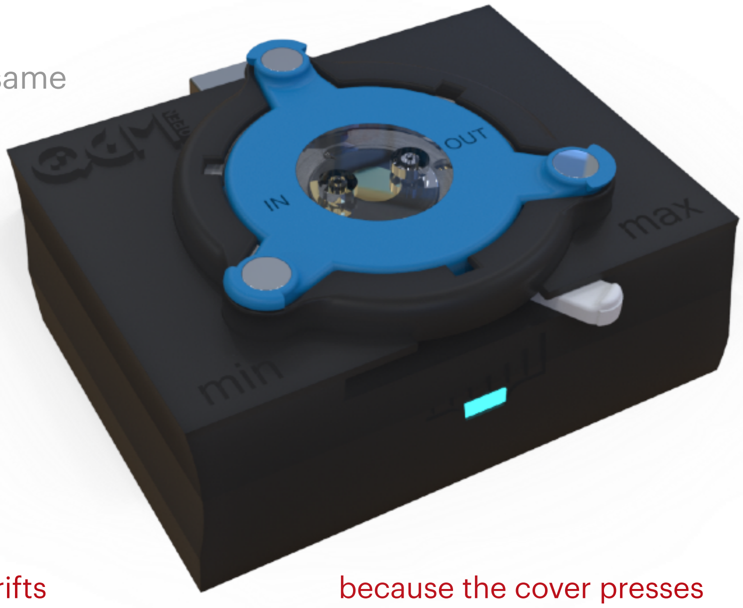
- Connect another tube to a classic syringe and the other side of the tube to the **outlet** of the fluidic cover

- **Aspirate** the liquid with the syringe and stop before the liquid enters the quartz chamber.

    - If the liquid remains stationary at the same level, the seal of the fluidic chamber is guarantee

    OTHERWISE:

    - To ensure the correct sealing, fine turn the lever counterclockwise, toward the "MAX" direction



⚠ It may be possible to observe frequency drifts because the cover presses too much on the quartz surface of the quartz. You can solve this by finely tuning the lever clockwise in the direction of minimum.
PLEASE BE CAREFUL ! Turning clockwise the lever may cause the cell to be flooded because it loses sealing.

HOW-TO

Using pumps

Best use of pumps in fluidic applications

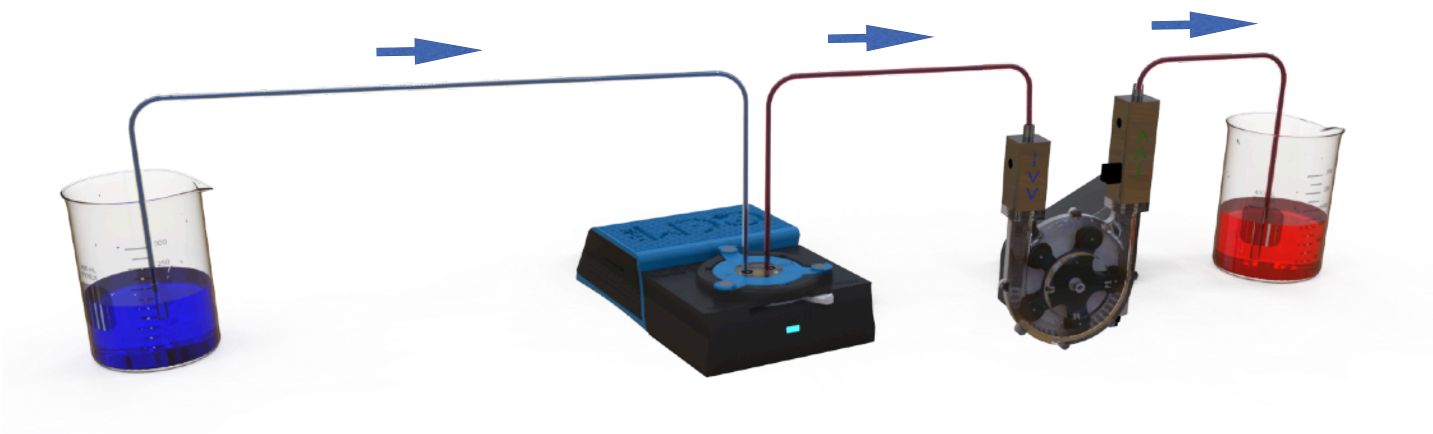
If you will use openQCM for measurement in fluidic environments you need to pay attention to few simple procedures, depending on the pump you will use.

Syringe pump: syringe pumps generally operate only in infusion mode so, if you use this kind of pump you should follow the following scheme.

PUMP-IN

Peristaltic pump: If you use this kind of pump you should follow the following scheme. You can also pump-in the fluid, but in order to reduce leakage risks, we suggest to use the showed setup.

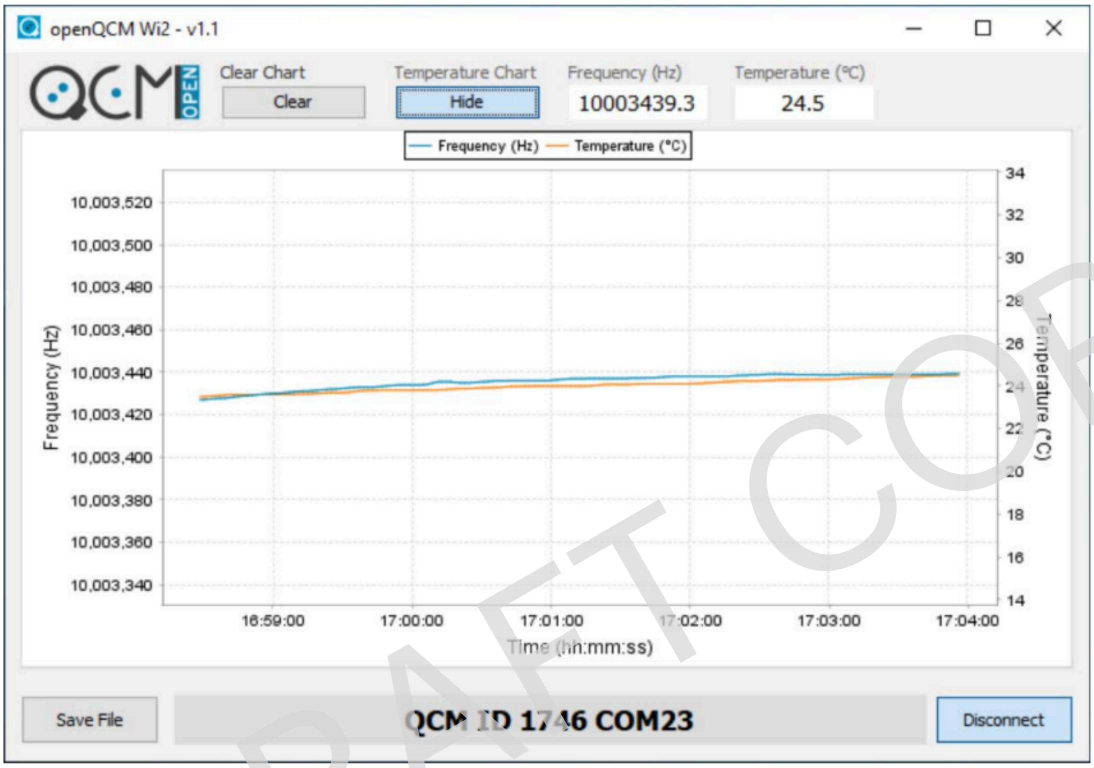
PUMP-OUT



SOFTWARE

Software GUI and Installation Guide

Just connect the device and launch your application



Name: **openQCM Q^{-1} GUI**
Version: **1.1**
Programming Language: **Java**
Author: **openQCM Team**
Supporting and powering the openQCM project: **Novaetech S.r.l**

The software interface provides all the necessary information to monitor in real time frequency variations of the QCM in a fully automatic way. The software allows you to uniquely identify the device connected to the COM port, so you can simultaneously plug multiple devices to your PC. The experimental data can be stored in a data file for post-processing and custom analysis.

Intended Audience: Science/Research/Engineering

Buttons:
- *Save File: open a dialog box for saving data in .txt file*
- *Connect / Disconnect button: open a dialog box for COM port connection*
- *Clear Chart: clear the current chart view*
- *Temperature Chart: Show / Hide temperature chart*

Indicators:
- *Frequency: display the current frequency value*
- *Temperature: display the current temperature value*

Chart:
- *Real–time chart of frequency and temperature values*SOFTWARE

SOFTWARE

Installation

Step-by-step tutorial

After downloading openQCM Q^{-1} Python application version 2.1 here:
https://openqcm.com/shared/q-1/openQCM_Q-1_py_v2.1.zip

Windows

1. Download and unzip openQCM_Wi2_v1-app.zip –
2. Open the unzipped folder and launch openQCM_Wi2_v1.exe application – For windows there is a driver stand-alone installer here

MacOs

1. Download and install the latest version of Java Runtime Environment version 8u* for Mac OSX x64
2. Download and unzip openQCM_Wi2_v1-macOS.zip
3. Browse to openQCM Wi2 directory and open the folder .../RXTX-lib-natives
4. Copy RXTXcomm.jar and librxtxSerial.jnilib and paste into /Library/Java/Extensions directory
5. Open the terminal and type the commands below by replacing username with your profile user name

```
export DYLD_LIBRARY_PATH=/Library/Java/Extensions
sudo mkdir /var/lock
sudo dscl . -append /groups/_uucp GroupMembership username
sudo chgrp uucp /var/lock
sudo chmod 775 /var/lock
```

6. – browse to openQCM Wi2 directory run openQCM_Wi2_v1.jar java application

More information available online here https://openqcm.com/openqcm-wi2-software

Technical Specifications

Sensors and core sensor

Number of sensors	Single quartz resonator sensor
Quartz sensors compatible and tested	5 MHz e 10 MHz , 14 mm blank diameter, - wrapped (single sided contacting)
Volume of measurement chamber	~ 50 μl

Measurement Specification

Physical quantities	Frequency
Measurement mode	Fundamental
Minimum Sampling time	~ 1 s

Hardware and Material Specification

Main case material	Nylon plastic PA2200
Sensor module materials	Viton (FKM) o-rings, Nylon plastic PA2200, PMMA or PTFE
Main Dimension	(L x W x H): 66 x 50 x 26 mm
Weight	43 g

Microprocessor Embedded

Teensy 3.2 based on ARM Cortex-M4	
Programming language	C++ arduino - language based code

Software

Real - time frequency and dissipation monitoring and data storage	
Programming language	Java
OS compatible	Windows, MacOS and Linux OS

Power

Main electronics	USB 5VDC powered (cable included)

Note: All specifications are subject to change without notice.

APPENDIX

Warning Notice

Temperature, Voltage and Materials

Temperature

The openQCM device hardware case is 3D-printed using Nylon material. It is heatproof to 80°C and higher temperatures may significantly change material properties. It is recommended to use openQCM electronics components and device (as a non-restrictive example Teensy microcontroller, openQCM Q-1 shield) in the working temperature range -40°C to 85°

Using the device at temperatures other than those indicated may significantly alter the materials and components resulting in a malfunction of the device. openQCM device is intended solely for use for scientific, R&D application, demonstration, or evaluation purposes Users handling the device must observe good engineering practice standards.

Voltage

openQCM Q-1 device is designed to be powered at a continuous voltage of 5VDC through connection to the USB port.

Power supply different from that indicated will damage the device. openQCM device is intended solely for use for scientific, R&D application, demonstration, or evaluation purposes Users handling the device must observe good engineering practice standards.

Materials

openQCM devices are realised with the 3D printing technique. The 3D printed case is made in Nylon strong and flexible plastic. This material is very adaptable, it is dishwasher safe and heatproof to 80°C / 176°F degrees. The material datasheet is available at this link: https://goo.gl/NzkbSG and the material safety datasheet is available here https://goo.gl/abrP8y The only materials of the sensor module that are in contact with the sample are those of the measurement chamber, consisting of the window cell and the oring. The standard window cell materials are PMMA acrylic glass (Plexyglass®) or PTFE synthetic fluoropolymer (Teflon®) standard oring is made of FKM Viton®.

It is strongly suggested not to use the PMMA window cell with organic solvents PMMA acrylic glass (Plexyglass®) material swells and dissolves in many organic solvents (such as ethanol); it also has poor resistance to many other chemicals due to its easily hydrolysed ester groups.

It is advisable to be very careful with aggressive chemical materials. openQCM device is intended solely for use for scientific, R&D application, demonstration, or evaluation purposes Users handling the device must observe good engineering practice standards.

APPENDIX

Open Hardware

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Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures, voltages and materials.

FCC Warning

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Final Notes

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