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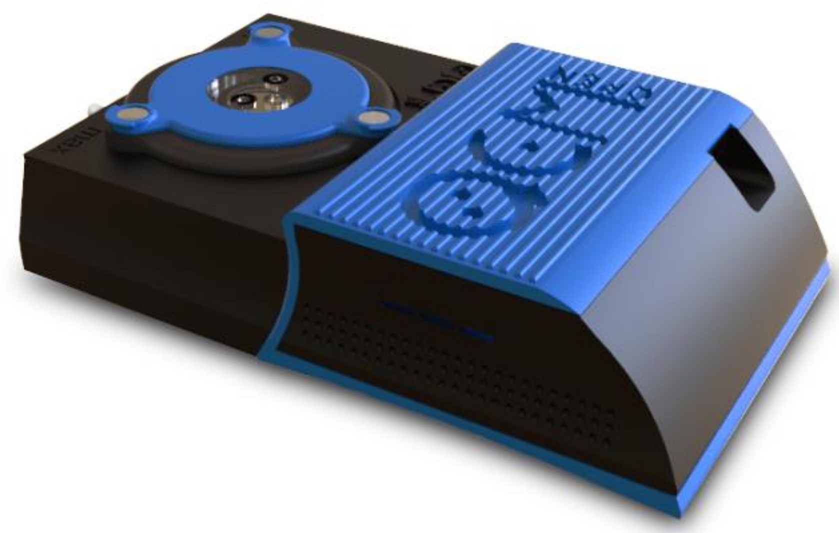
openQCM Wi2 User's Guide

openQCM Wi2 Quartz Crystal Microbalance Test Equipment
for frequency monitoring
Sensor Module Quick Instructions: How to use the sensor module properly



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Intro

openQCM test equipment is released as a scientific open source device, and it is intended solely for use for SCIENTIFIC, RESEARCH and DEVELOPMENT APPLICATION, DEMONSTRATION, OR EVALUATION PURPOSES and is not considered to be a finished end-product fit for general consumer use.

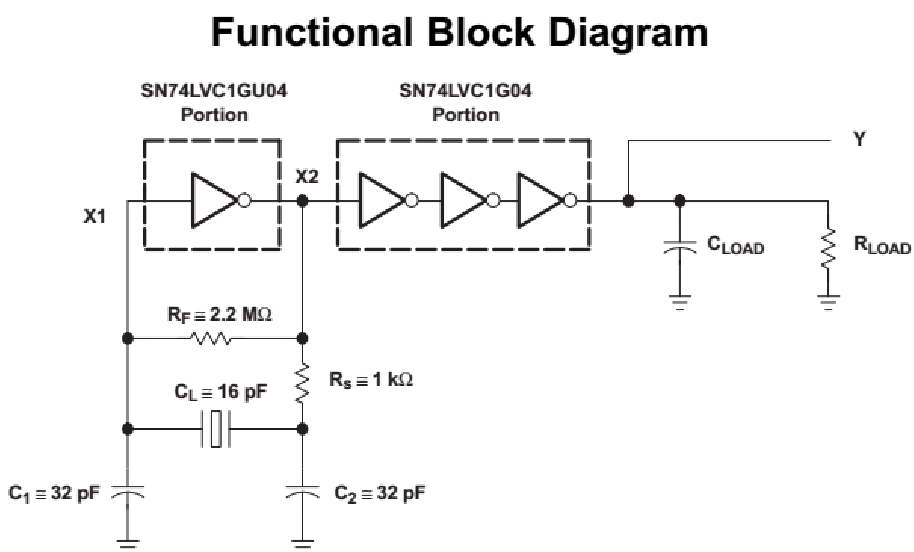
openQCM Wi2 is the new open hardware test equipment based on Quartz Crystal Microbalance, a surface sensitive technology capable of measuring phenomena at molecular scale.

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.

Electronics



a) Logic Diagram View

openQCM Wi2 is a test equipment for scientific application simple and accurate at the same time. The test equipment is suitable both for your first use of QCM technology and for more advanced and skilled users.

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.

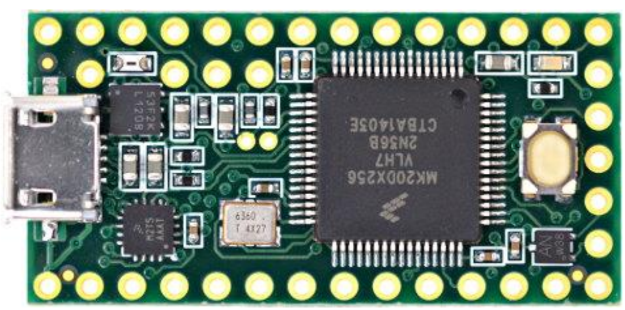
The Pierce is a series-resonant circuit with many notable characteristics. It can operate in a wide range of frequencies (roughly speaking from kHz to 100 MHz). It shows a very good short-term stability because the crystal's source and load impedances are mostly capacitive rather than resistive.

The circuit provides a large output signal and simultaneously drives the crystal at a low power level.

The circuit uses the crystal oscillator driver SN74LVC1GX04 device, which combines an inverter with unbuffered output with an additional buffered inverter for signal conditioning. The additional buffered inverter improves the signal quality of the crystal oscillator output. The device is designed for 1.65-V to 5.5-V VCC operation and it is suitable for frequencies ranging from 15 kHz to 28 MHz.

The 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. The Rs resistance is the current-limiting resistor. Rs is used as the integrating resistor for the Rs C2 phase-lag network. Rs and C2 form a low-pass filter and their use is intended to reduce spurious frequencies. RF is the feedback resistor which provides negative DC feedback around the inverter, in order to bias the inverter in the linear region so that oscillation will start when power is turned on. Typical value is chosen between 1 MΩ to 10 MΩ.

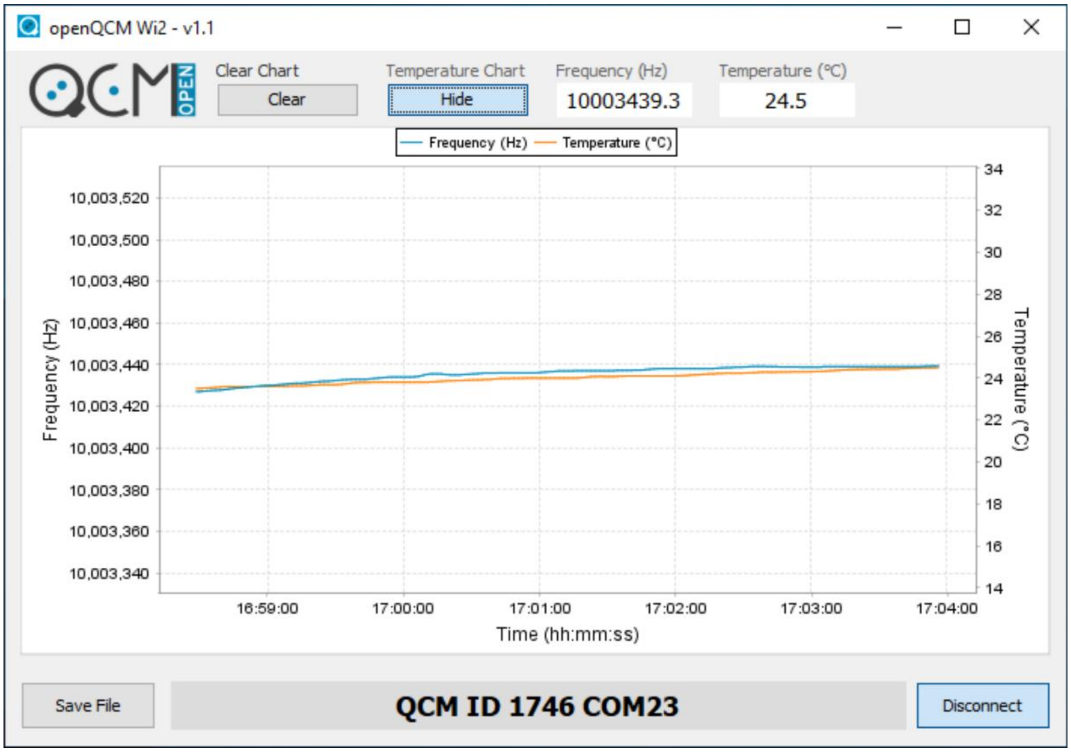
Teensy Microcontroller 3.2



The square – wave output of the Pierce's oscillator is fed to Teensy microcontroller hardware counter. The Teeny microcontroller is a powerful and easy-to-use USB development board created by Paul Stoffregen at PJRC. openQCM Wi2 uses a Teensy 3.2 board, with a 32-bit 72 MHz Cortex-M4 microprocessor (model: MK20DX256VLH7), which features a 16-bit hardware counter.

The signal 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.

Software GUI and Installation Guide



Software GUI

Button:

- 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

Indicator:

Frequency: display the current frequency value

Temperature: display the current temperature value

Chart:

Real – time chart of frequency and temperature values

Installation Guide

Windows OS

– Download and unzip openQCM_Wi2_v1-app.zip

– Open the unzipped folder and launch openQCM_Wi2_v1.exe application

– For windows there is a driver stand-alone installer here

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Mac OS

– Download and install the latest version of Java Runtime Environment version 8u* for Mac OSX x64
– Download and unzip openQCM_Wi2_v1-macOS.zip
– Browse to openQCM Wi2 directory and open the folder …/RXTX-lib-natives
– Copy RXTXcomm.jar and librxtxSerial.jnilib and paste into /Library/Java/Extensions directory
– 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
```

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

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

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How to Setup openQCM Wi2 Sensor Module

1. The sensor module has a pair of pogo pins to ensure connection to the quartz crystal sensor. The first couple is suitable for 14 mm diameter quartz crystal one sided contacting

2. Insert the quartz crystal into the sensor module housing, making sure that the electrodes on the rear surface of the quartz are in contact with both pogo pins

3. Close the sensor module with the cover, while the closing lever is positioned on the min

4. Turn the lever counterclockwise, in the direction of maximum, to ensure the seal of the sensor module

1

2

3

4

How to Finely Check the Sealing of the Sensor Module

- Connect the tubes to the flow cover.
- Connect one tube to the liquid reservoir (inlet) and the other tube to a syringe / pump (outlet)
- Aspirate the liquid with the syringe / pump and stop before the liquid enters the quartz chamber.
  - if the liquid remains stationary at the same level, the seal of the chamber is guaranteed. Otherwise:
  - the seal of the chamber is not guaranteed: turn the lever counterclockwise, in the direction of maximum, to ensure the seal of the sensor module.

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 turning the lever clockwise in the direction of minimum.
PLEASE BE CAREFUL ! Turning clockwise the lever too far towards the minimum may cause the cell to be flooded because it loses sealing.

It may be possible to observe tilting of the top cover, which can prevent the measurement cell from being sealed properly. Gently press on the top cover to check that it does not tilt, otherwise sealing may not be guaranteed. If the top cover tilts, it is suggested that you turn the adjustment lever clockwise, in the minimum direction, to prevent the top cover from tilting.
PLEASE BE CAREFUL ! Turning clockwise the lever too far towards the minimum may cause the cell to be flooded because it loses sealing.

Technical Specification

Case Dimension & Materials	Fluidic window	Open Window
Dimensions: 66 x 50 x 26 mm Weight: 43 g	Materials: PMMA or PTFE 14 mm internal volume: 50 µL	Materials: PMMA or PTFE Sample volume: range from 10 µl to 100 µl
Case Material: Nylon	25.4 mm internal volume: 200 µL (above the sensor) O-ring: FKM	O-ring: FKM

Temperature, Voltage and Material Warning Notice

Temperature

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

The vibration frequency of the quartz sensor depends on the temperature, for this reason a temperature sensor has been mounted inside the sensor module.

It is suggested that the measurement environment of the laboratory be kept constant, so that no variation (in particular *drift*) in the vibration frequency of the quartz are observed.

Voltage

openQCM Q-1 test equipment 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 test equipment.
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Material

openQCM test equipment are realized 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 hydrolyzed ester groups.

It is advisable to be very careful with aggressive chemical materials.
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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 test equipment. This notice contains important safety information about temperatures, voltages and materials.

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