
IN
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OpenQCM Q^{-1}

QUARTZ CRYSTAL MICROBALANCE WITH DISSIPATION MONITORING

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 20 April 2023
Version: 1.0

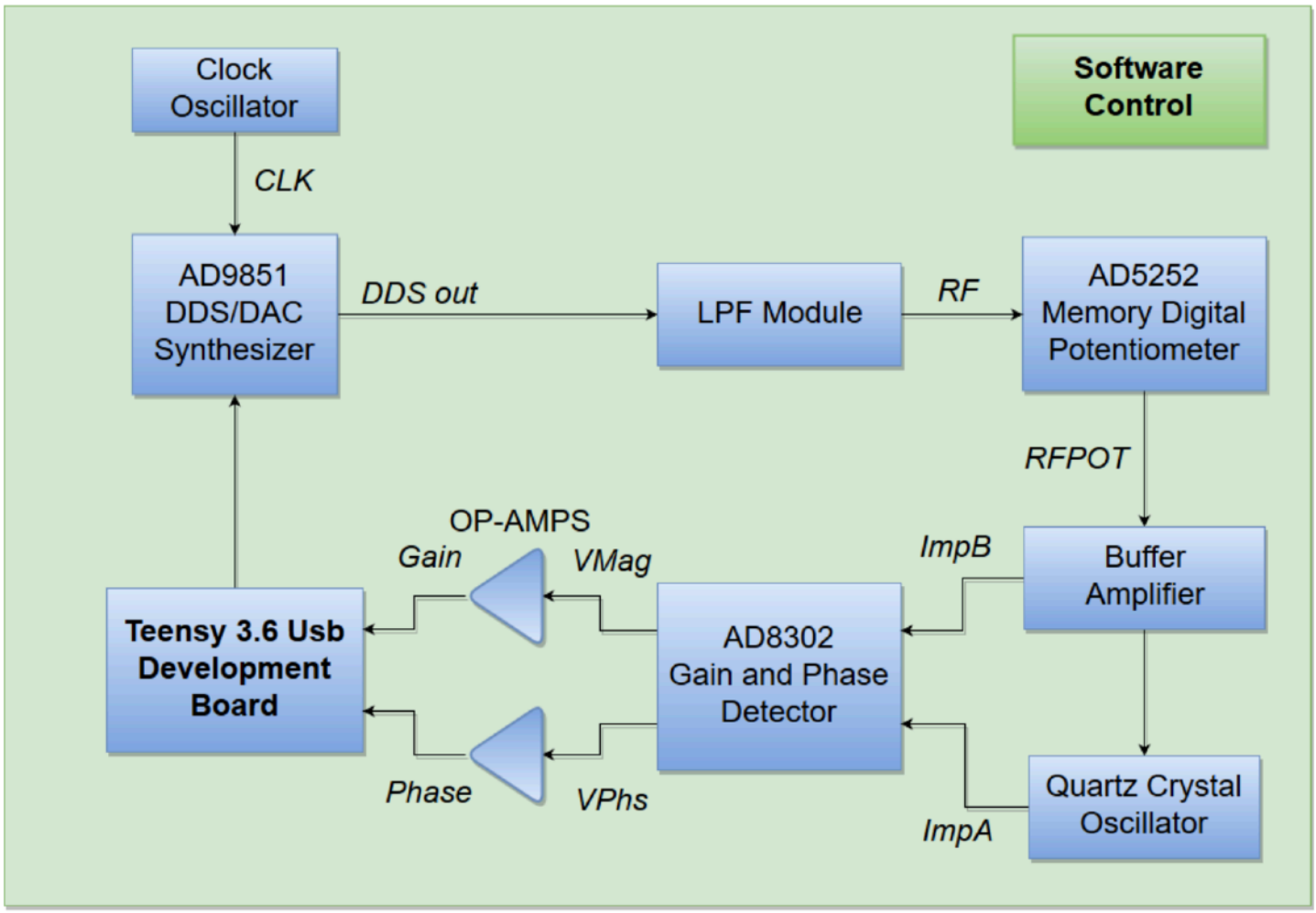
Why openQCM

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

openQCM Q-1 is a Quartz Crystal Microbalance instrument capable of measuring simultaneously frequency and dissipation variations. The device is therefore capable of measuring both variations in mass and the viscoelastic properties of the material on the surface of the quartz crystal

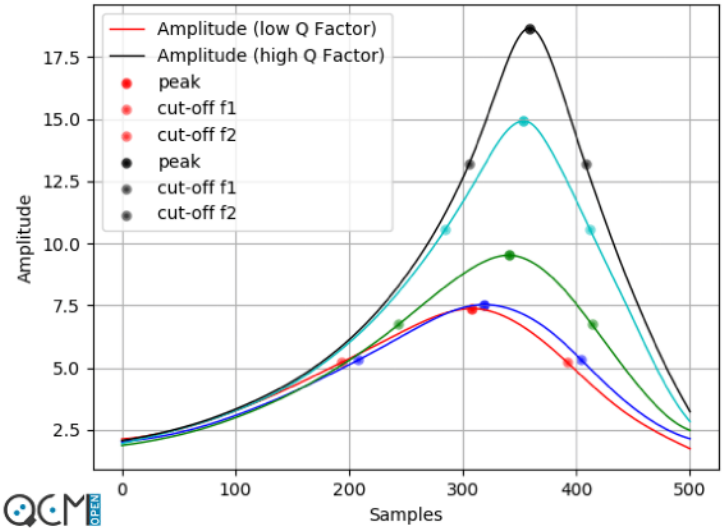


The electronics mainly consists of a scalar network analyser, the main block diagram is showed in figure. The scheme of measurement follows the principle of passive interrogation of the quartz sensor by sweeping around the resonance frequency. The actuation signal is generated using the AD9851 DDS/DAC frequency synthesiser and the output signal is read by AD8302 gain and phase detector, which can measure both the magnitude ratio (gain) across the quartz crystal and the phase difference between the actuation and transmitted signal. The analysis of the gain curve allows the characterisation of the sensor by measuring simultaneously the resonance frequency and quality factor. The main advantage of the

scheme of measurement is the possibility to measure quartz sensor parameters in isolation without an external circuity influence. openQCM Q-1 electronic consists mainly of two boards: i) the main board features the network analyser and Teensy microcontroller, and ii) the secondary board which is inserted in the fluidic cell, which features the electro-mechanical connections with the quartz crystal sensor using pogo-pin and also a temperature sensor which is mounted as close as possible to the quartz crystal sensor, in order to measure the temperature inside the fluidic cell.

HOW FREQUENCY AND DISSIPATION ARE MEASURED

Each resonance curve is built point by point by sweeping in frequency around the fundamental and overtone harmonics. Once the whole curve is recorded in a buffer, the Frequency is measured by means of a peak detection algorithm. Dissipation is measured by evaluating the quality factor (Q-factor), that is the bandwidth at -3dB for each specific curve.



Q-factor is related to the dissipation D, which is a dimensionless parameter defined as the ratio between the energy loss and stored in each cycle:

Dissipation is an important physical observable because it is related to the viscoelastic properties of the sample in contact with the quartz crystal surface.

ELECTRONICS

Mainboard

The electronics mainly consists of a network analyser that passively interrogates the quartz sensor by sweeping around its resonance frequency.

The actuation signal is generated using the AD9851 DDS/DAC frequency synthesiser and the output signal is read by AD8302 gain and phase detector, which can measure both the magnitude ratio (gain) across the quartz crystal and the phase difference between the actuation and output signals. The analysis of the gain curve allows the characterisation of the sensor by measuring simultaneously the resonance frequency and quality factor.

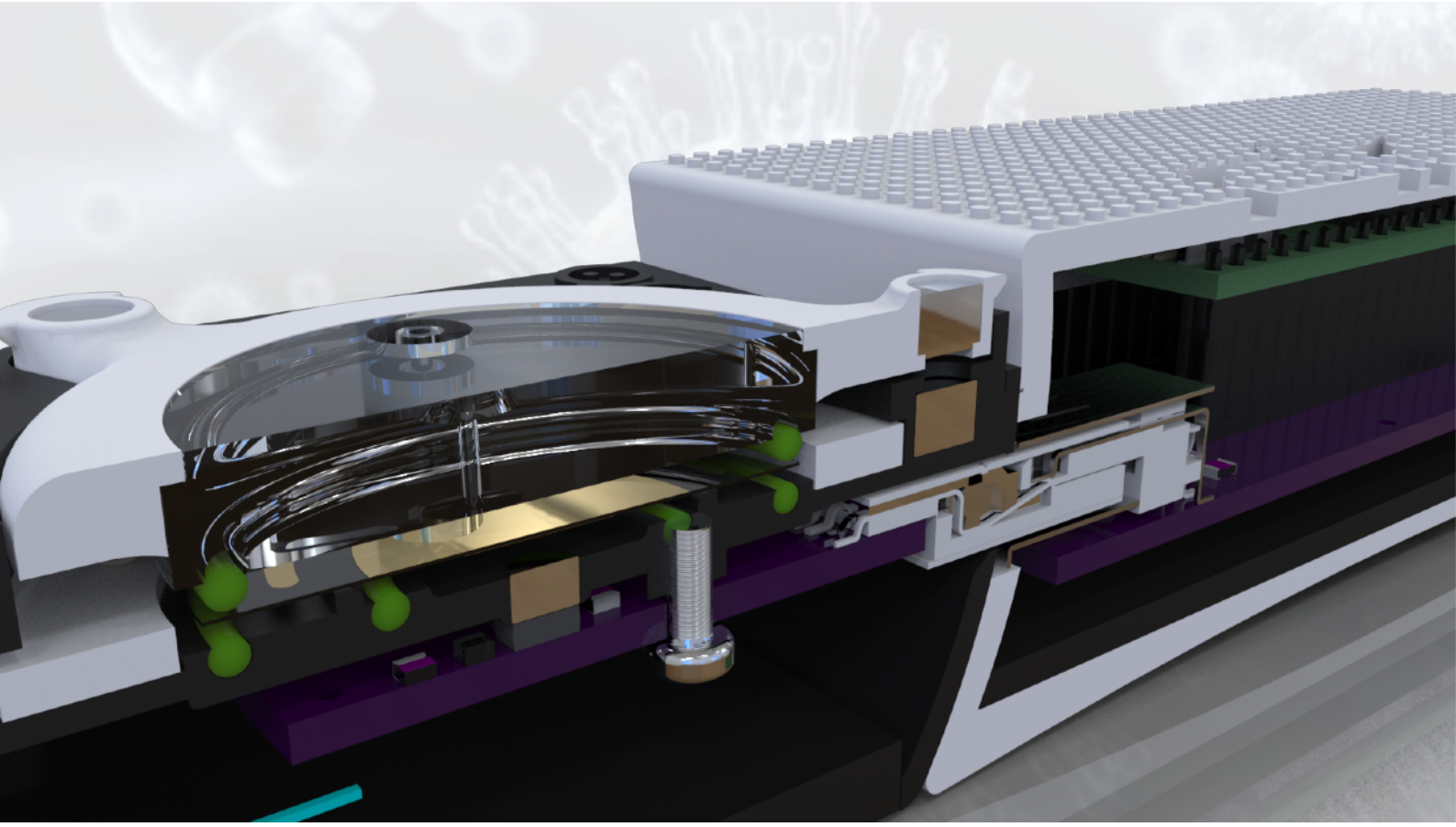
The main advantage is the possibility to measure quartz sensor parameters in isolation without external circuity influences.

The mainboard is controlled by a Teensy 3.6 (developed by Paul Stoffregen) , that mounts a ARM Cortex-M4. The board is characterised by a lot of functionalities, the most interesting one is the analog input ADC with an real resolution of 13 bits. It means that over the full-scale range of 3.3 volt it is possible to measure input voltage variations with a resolution 0.4 mV/bits.

HARDWARE

The Design

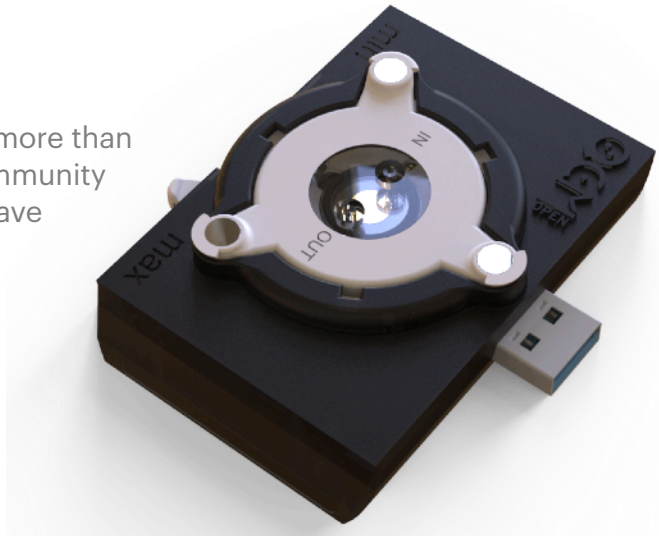
A new concept design of Quartz Crystal Microbalance



One simple gesture to mount it! The main electronics case is composed of 2 elements produced in 3D printing. With an innovative slot locking system, 2 simple screws are sufficient to ensure compactness and protection for the electronics. An ergonomic design ensures maximum handling for an instrument that was born to be portable.

$$D = \frac{E_{dissipated}}{\pi E_{stored}} = \frac{1}{Q}$$

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.



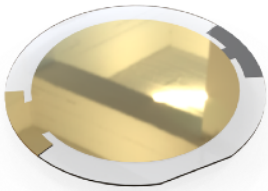
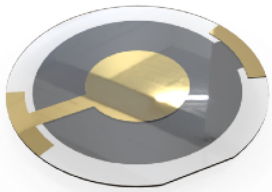
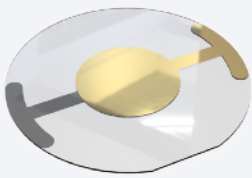
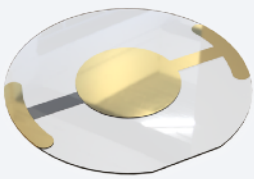
- pogo-pin sensor contacts;
- multi quartz dimension compatibility;
- multi-frequency housing compatibility;
- fine regulation of O-ring; pressure;
- Integrated temperature sensor;
- magnetic back-reaction to sealing.

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		

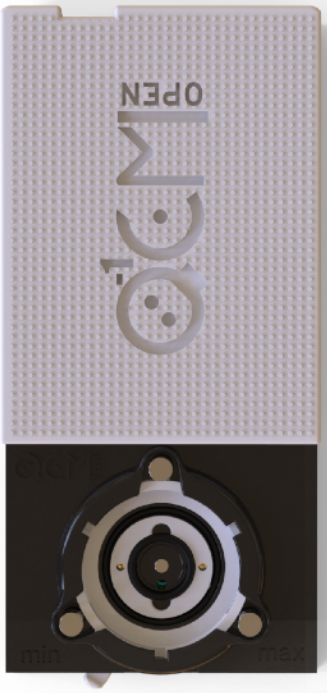
HOW-TO

Setup openQCM Q^{-1} Sensor Module

Preliminary actions for the correct sensor housing

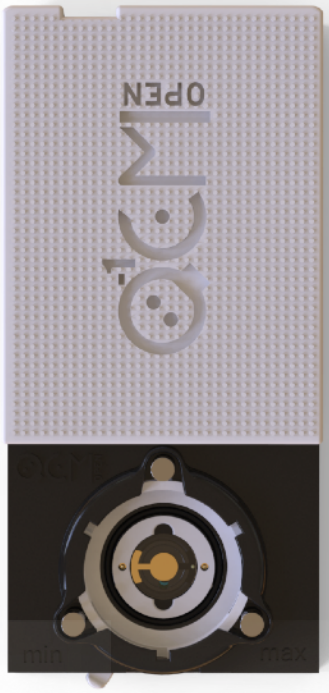
1.

Remove the top fluidic cover



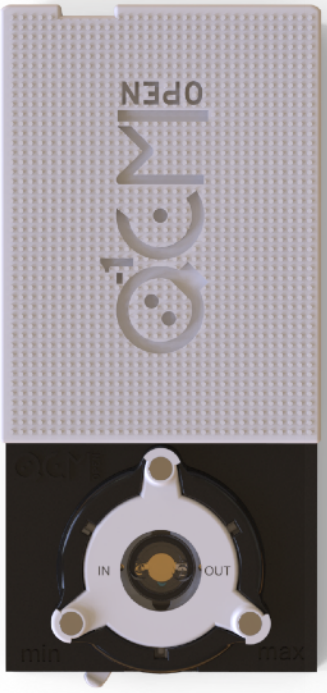
2.

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 pogo pins



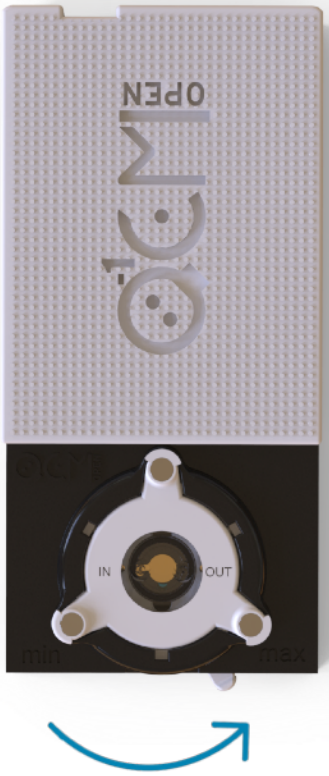
3.

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.



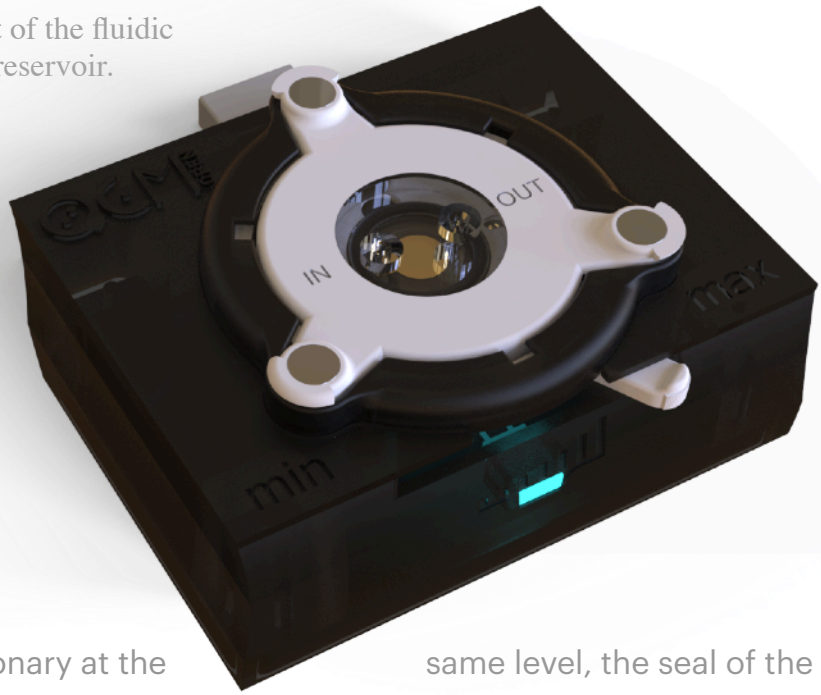
HOW-TO

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

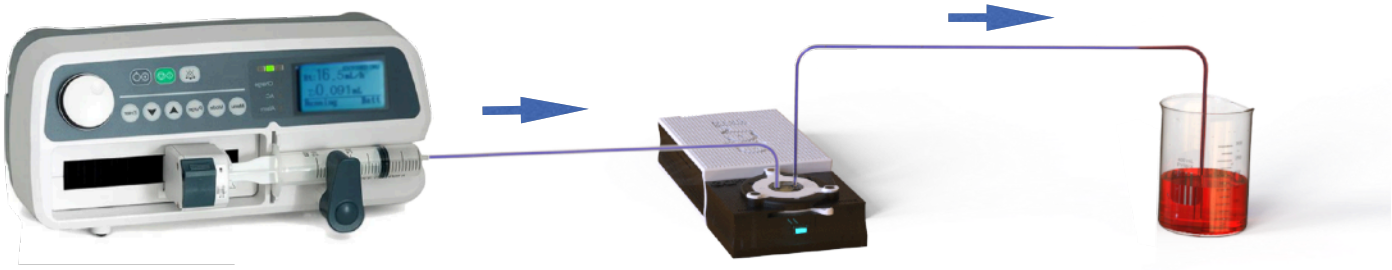
Using pumps

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.

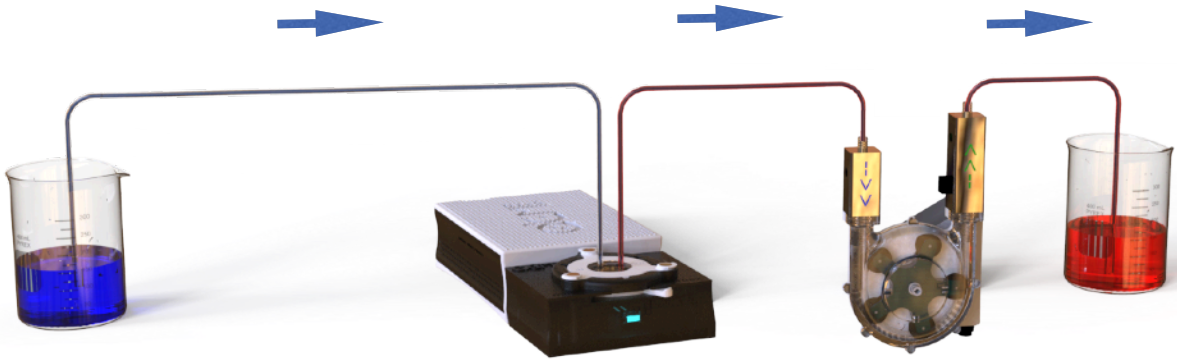
Syringe pump: syringe pumps generally operate only in infusion mode so, if you use this kind of pump you should follow the following scheme.

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



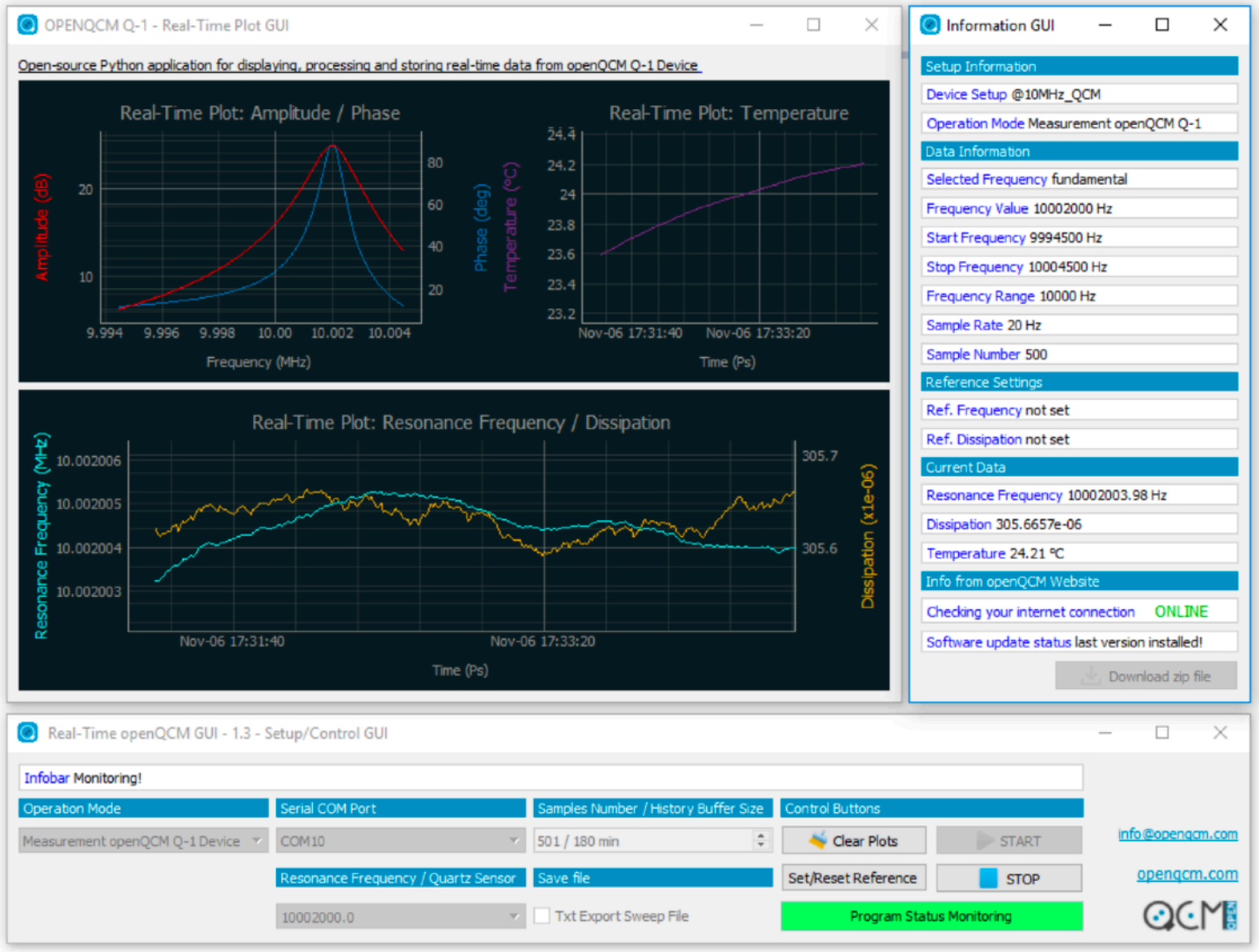
SOFTWARE

GUI Python version 2.1

Minimum requirements

openQCM software id an open-source Python application that displays, process and stores real-time data from the openQCM Q-1 Device. The application includes internal and external packages need for using this software.

Intended Audience: Science/Research/Engineering



Name: **openQCM Q^{-1} GUI**
Version: **2.1**
Programming Language: **Python**
Author: **openQCM Team**
Supporting and powering the openQCM project: **Novaetech S.r.l**

SOFTWARE

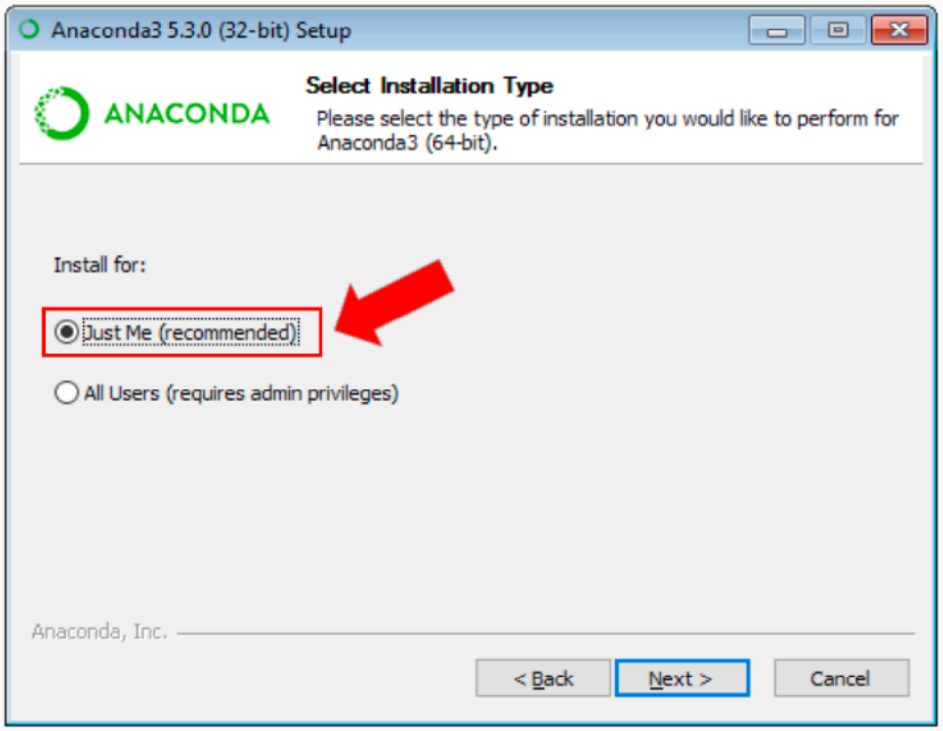
Installation

Step-by-step tutorial

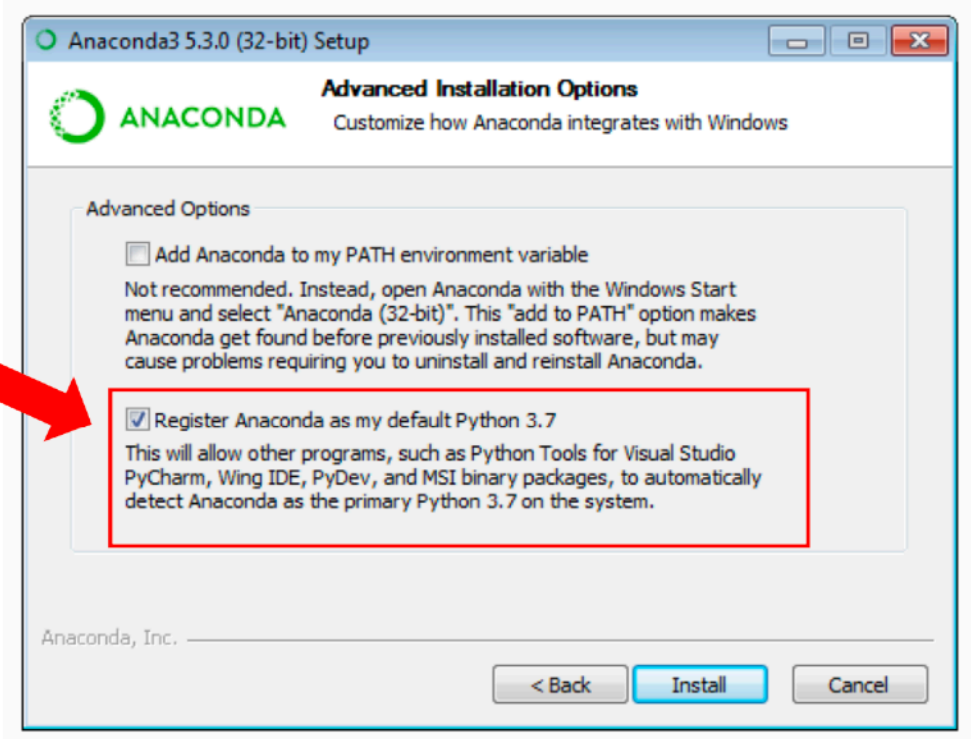
After downloading openQCM Q^{-1} Python application version 2.1 here:
https://openqcm.com/shared/q-1/openQCM_Q-1_py_v2.1.zip

Windows **MacOS**

1. Download and install Anaconda3 for Python 3.7 version Anaconda3-5.3.0
   https://www.anaconda.com/download/
   For the installation type, it is best to select *"Just Me"*; if you select *"All Users"* you must complete the console steps below in an elevated console.



2. During Anaconda3 installation select the check mark shown in the figure below:



3.

4.

5.

6.

3. Open Anaconda3 prompt (Windows) or terminal (macOS) and type (install/upgrade Python packages) :

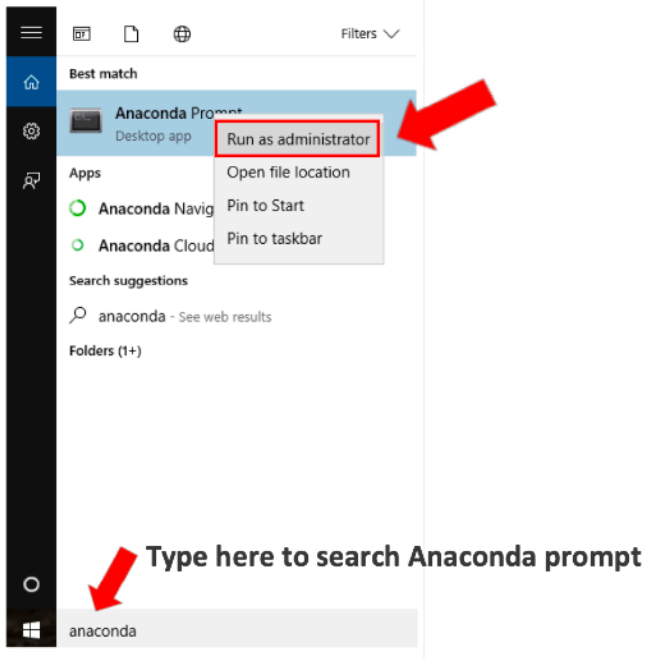
```
conda install pyqtgraph pyserial

python -m pip install --upgrade pip

python -m pip install --upgrade h5py

pip install progressbar
```

If you choose to install Anaconda for "*All Users*" you will need to set administrator privileges on the Command Prompt. Right click "*Anaconda Prompt*" and choose "*Run As Administrator*". If you do not want to do this every time you will need to set the permissions on the entire Anaconda directory for user to Full Access.



Linux

1. Type the command below by replacing username with that of your pc change permission of Anaconda3

```
sudo chown -R username:username /home/username/anaconda3
```

2. Open Anaconda3 terminal and type (install/upgrade Python packages) :

```
conda install pyqtgraph pyserial
pip install --upgrade pip --user
pip install progressbar --user
```

3. Set permission on serial port

```
sudo usermod -a -G uucp username
sudo usermod -a -G dialout username
```

4. Logout and Login

SOFTWARE

Starting to use openQCM GUI

Step-by-step tutorial

Start the application from Anaconda3 prompt

1. Launch Anaconda3 prompt
2. Browse to the openQCM Q-1 Python software main directory

```
...\openQCM_Q-1_py_v2.1\OPENQCM\
```

3. Start the application main GUI by typing the command

```
python -m openQCM
```

Start the application double-clicking *app.py* file

You can make executable and launch *app.py* Python file

1. Browse to the openQCM Q-1 Python software main directory

```
...\openQCM_Q-1_py_v2.1\OPENQCM\
```

2. Right click on app.py file -> open with -> choose another app in this PC
3. Browse to Anaconda3 directory on your PC

```
C:\Users\[your_user_name]\Anaconda3
```

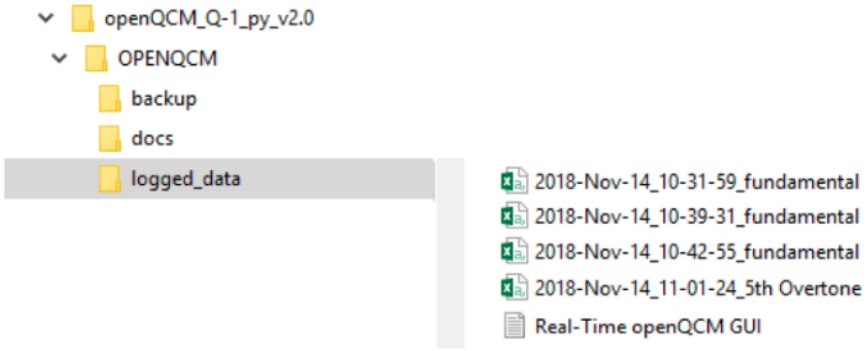
4. Select *python.exe* executable file
5. Double-click on app.py file ( ) in the OPENQCM Python software main directory (see folders and program files below)

Folders and program files

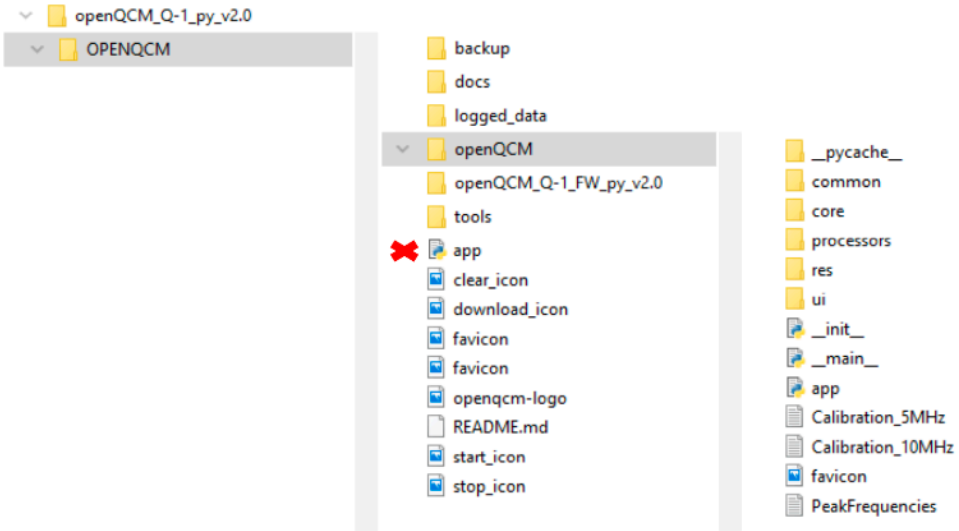
The figure below shows the main folders and the program files.

- backup folder includes a copy of system files;

- logged_data folder includes stored data files (see below, Measurement openQCM Q-1 device Operation Mode) and a log file (*Real-Time openQCM GUI.txt*);



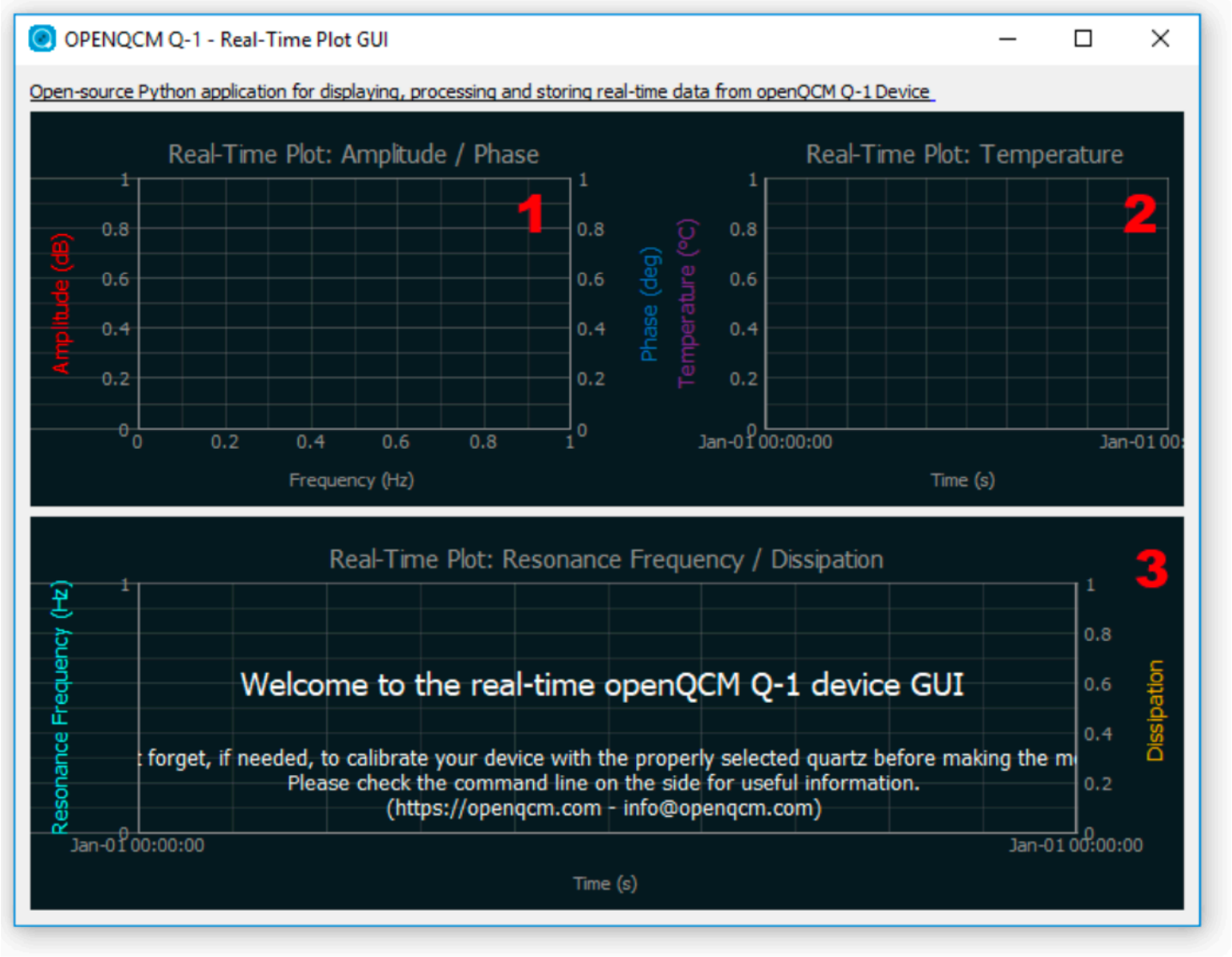
- openQCM_Q-1_FW_py_v2.1 folder includes the latest version of then openQCM Q-1 firmware version Python 2.1 for Teensy 3.6 Development Board.



SOFTWARE

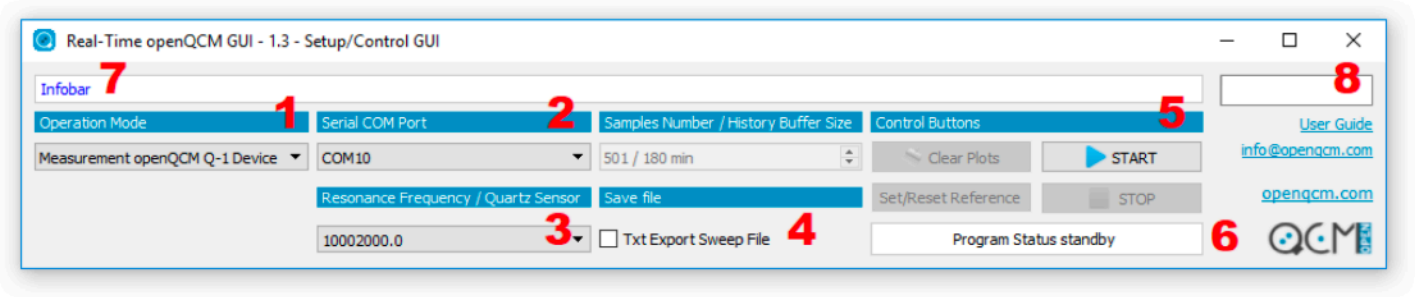
openQCM Q-1 GUI Description

Main interface



The main GUI of openQCM Q-1 Python software version 2.1 is showed in figure. The main GUI consists of three separate windows: 1.'**Setup/Control GUI**', 2.'**Real-time Plot GUI**' and 3.'**Info GUI**'. The detailed description of the functions of each GUI is given below.

1. Setup/Control GUI



Drop-Down Menu Control:

1. Select Operation Mode: "Measurement openQCM Q-1 device" or "Calibration openQCM Q-1 device".

2. *"Serial COM Port"* selects the available COM port, note that the software shows only the port connected to the device.

3. *"Resonance Frequency/Quartz Sensor"* drop-down menu: selects the working resonance frequency (fundamental and overtones) in *Measurement openQCM Q-1 device* mode, or select the properly fundamental quartz frequency (i.e. @10MHz or @5MHz) in *Calibration openQCM Q-1 device* mode.

Save File - Radio Button Control:

4. Flag "Txt Export Sweep File" radio button to log data for each sweep cycle in Measurement openQCM Q-1 device operation mode (raw data).

Control Buttons:

5. "START" starts a continuous measurement procedure in Measurement openQCM Q-1 device operation mode OR start the calibration procedure in Calibration openQCM Q-1 device operation mode.

   "STOP" stops the acquisition procedure in Measurement openQCM Q-1 device operation mode. Clear Plots: clear all real-time plots (works only in Measurement openQCM Q-1 device operation mode).

   "Clean Plots" cleans all plots in the Real-time Plot GUI (works only in Measurement openQCM Q-1 device operation mode).

   "Set/Reset Reference" sets a zero reference line corresponding to the current data: resonance frequency and dissipation respectively (works only in Measurement openQCM Q-1 device operation mode).

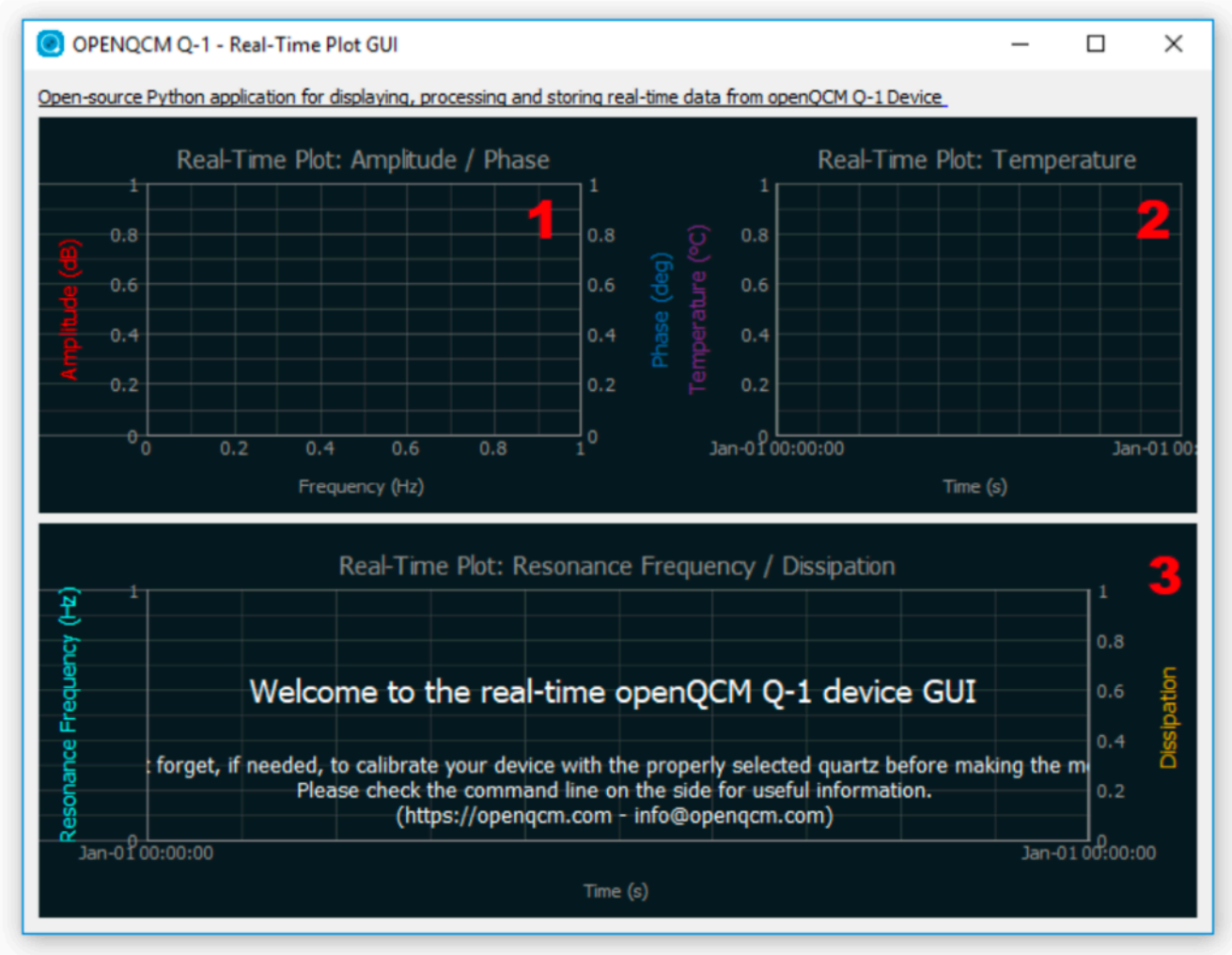
Indicators:

6. *"Infobar"* shows useful additional information, which is shown also in the anaconda prompt.

7. *"Program Status"* indicator shows the current status of the program and eventually alerts about exceptions (e.g. calibration warnings). Please note that the Program Status indicator changes color (yellow , green and red) depending on the information.
   By clicking on the text "*openqcm.com*" you can access our website or by clicking "*info@openqcm.com*" you can send us an e-mail. In the latest version of the software you are able to refer to this user's guide online by clicking on the text "*User Guide*".

8. A progress bar is used to show a user how far along is in a process (works in *Measurement/ Calibration openQCM Q-1 device* operation mode).

2. Real-Time Plot

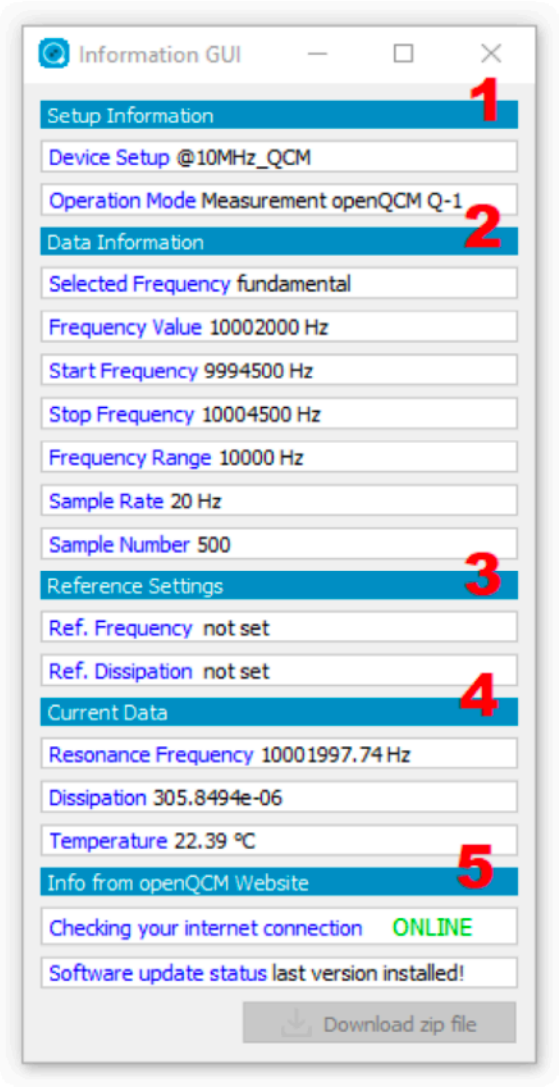


1. *"Amplitude /Phase"* displays the amplitude and phase curve during both operation modes.

2. *"Temperature"*: displays the current value of the temperature, measured by sensor embedded on
the fluidic cell only during *Measurement openQCM Q-1 device* operation mode.

3. *"Resonance Frequency/Dissipation"* real-time chart simultaneously displays the current frequency and dissipation value, calculated at the end of each sweep in *Measurement openQCM Q-1 device*
operation mode.

3. Info GUI

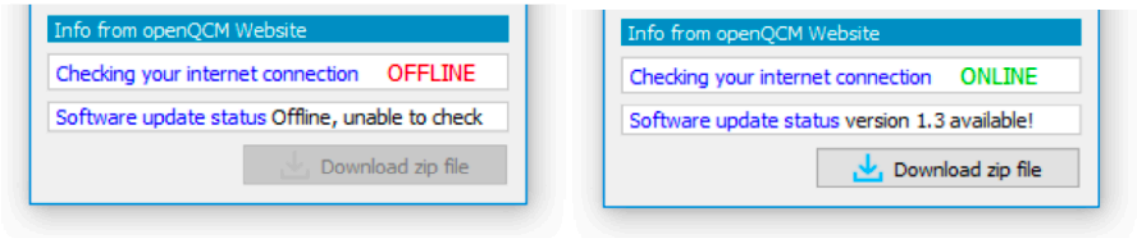


1. *"Setup Information"* shows the Quartz Sensor and the selected Operation Mode;

2. *"Data Information"* shows information about selected working resonance frequency
"Reference Settings" indicates the current reference value for resonance frequency and dissipation if *"Set/Reset Reference"* control button is clicked (works only in *Measurement openQCM Q-1 device* operation mode).

3. *"Current Data"* shows the current value of frequency, dissipation and temperature in real-time in *Measurement openQCM Q-1 device* operation mode.

4. *"Info from openQCM Website"* shows if the user is connected to internet and checks if a new version of the software is available. In this case, the *"Download zip File"* button is enabled.



Example: Internet connection Offline (on the left) and new software version available (on the right)

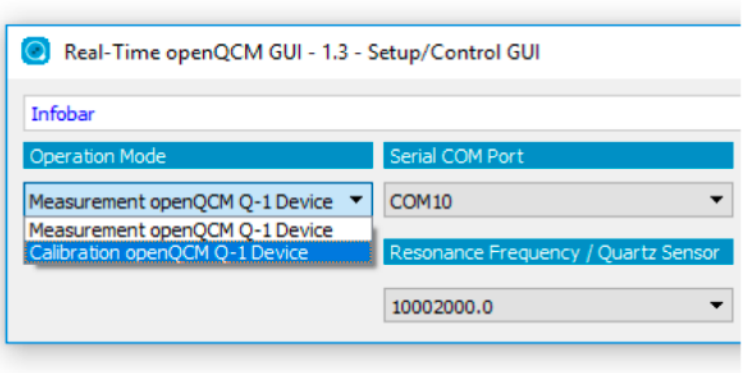
SOFTWARE

Calibration

Each time the sensor is replaced, a calibration procedure must be performed

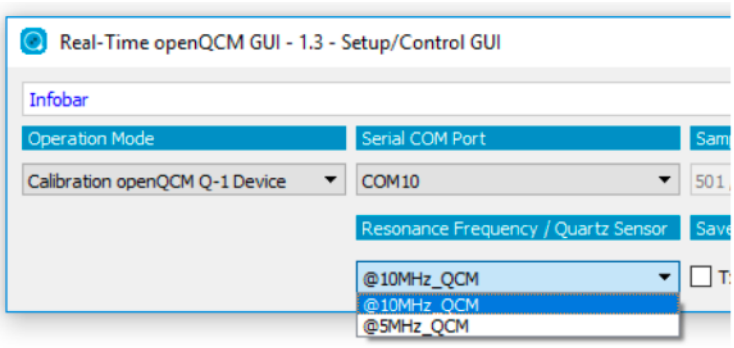
1. Select Calibration

   By using the **Setup/Control GUI,** open the #1 Drop-down menu and select *"Calibration openQCM Q-1 Device"*



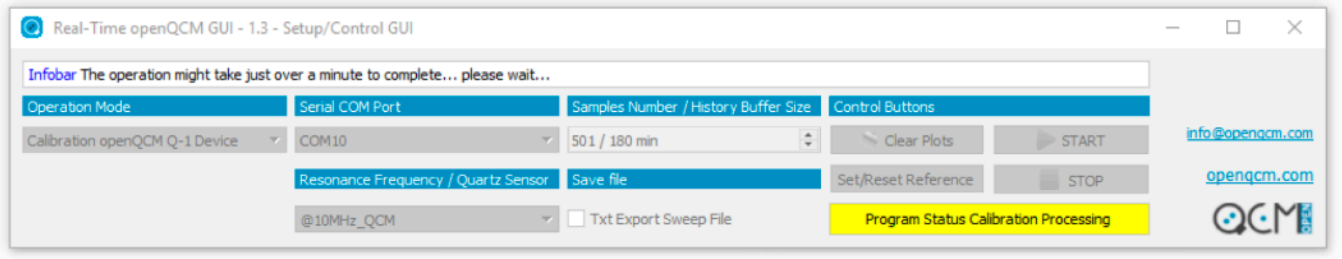
2. Select the fundamental frequency

   From #3 the Drop-down menu select the resonance frequency of the used sensor: 5MHz or 10MHz.

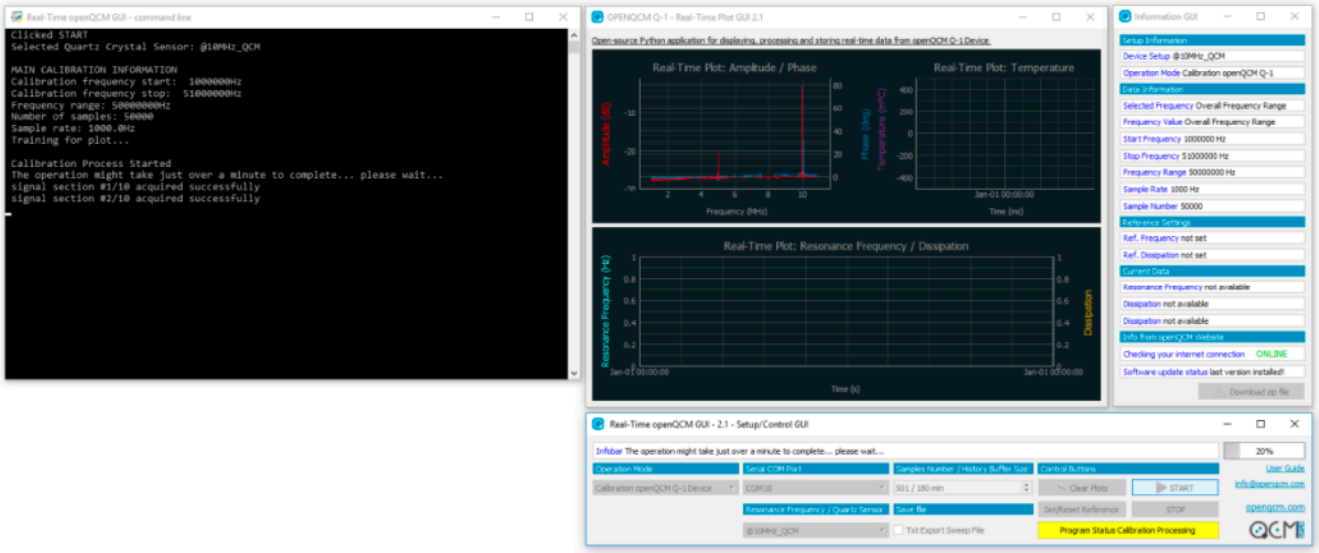


3. Start the calibration

   Press the *START* button for starting calibration procedure. Follow the indication in the Anaconda prompt or in the *Infobar* to check info and progress of the calibration (please note that calibration takes roughly 104 sec to complete and the *Program Status indicator* has turned yellow). You can read in *Infobar* or in anaconda prompt: *"The operation might take just over a minute to complete... please wait..."*

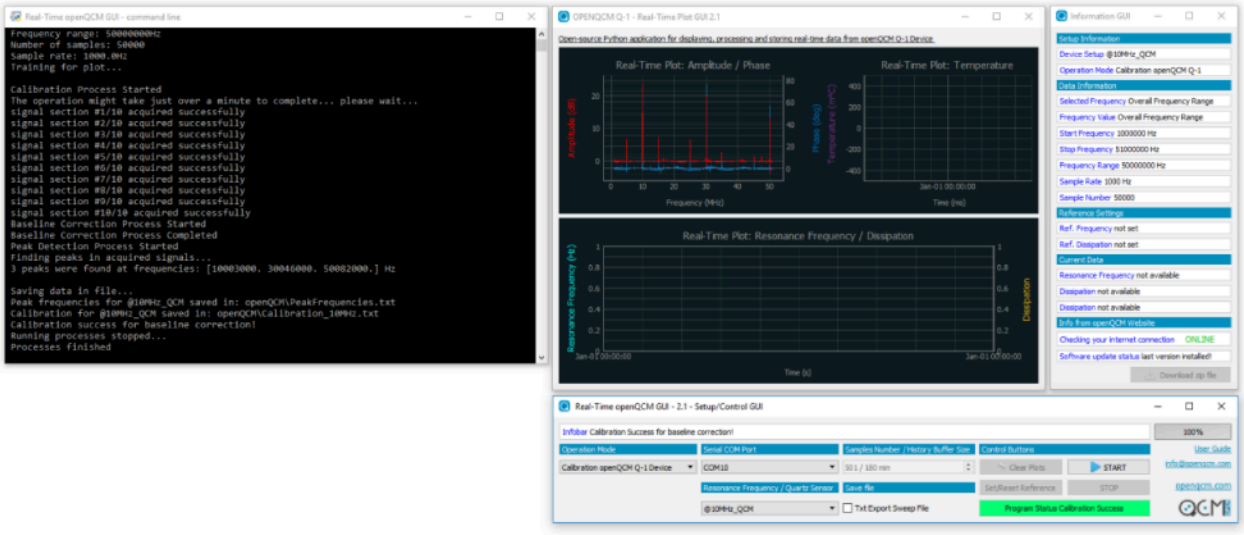


The calibration process is visually represented by means a realtime plot. Furthermore, an error or a warning will be notified when the first block is executed without waiting for the following blocks to be completed (see *Exceptions and Warnings during Calibration Operation Mode*).



4. Calibration success

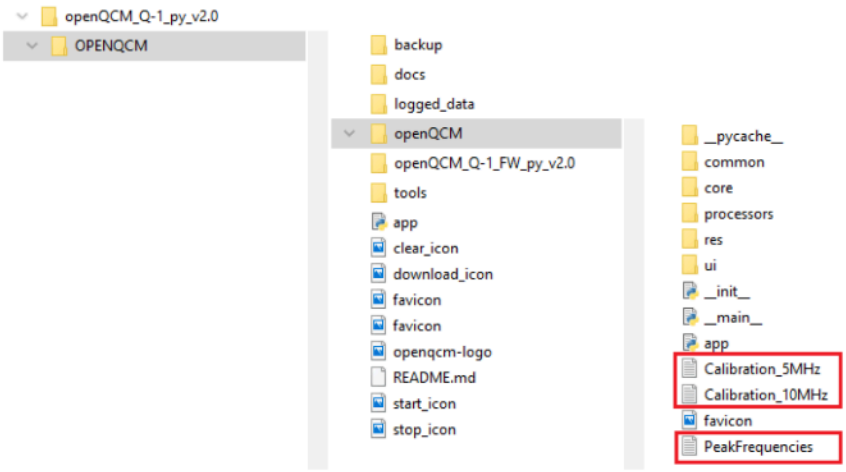
   When you see the following message in the Infobar or in the Anaconda prompt: "Calibration success for baseline correction!" and the Program Status indicator turns green (see figure), the



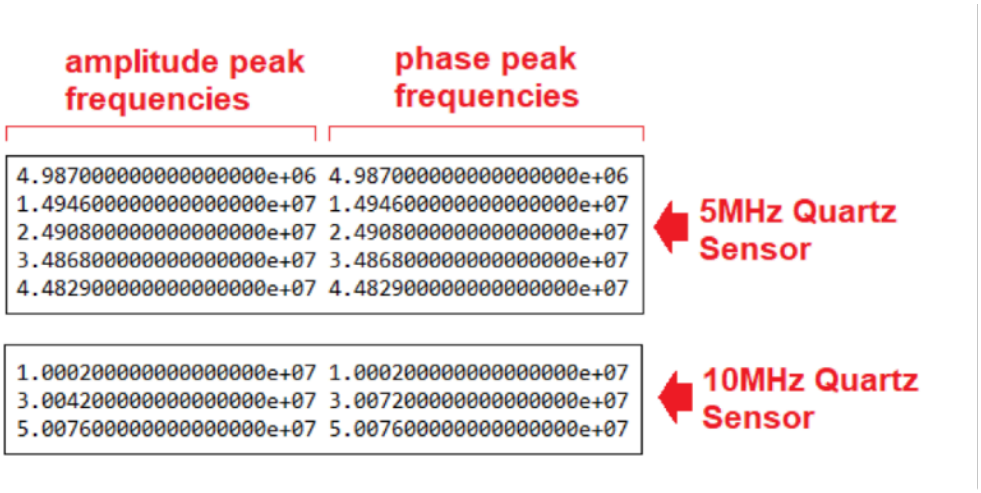
calibration procedure has been completed successfully. Please note that the peak detection algoritxhm has some computational complexity and takes some time. The time required to complete this operation also depends on the performance of your PC.

Calibration files and reports

Once the calibration procedure has been successfully completed, the system files (Calibration_5Mhz.txt or Calibration_10MHz.txt - depending on the quartz sensor type @5Mhz or @10MHz - and the file PeakFrequencies.txt) are saved. **Please note that no files are saved if the calibration procedure failed** (see below Exceptions and Warnings during Calibration Operation Mode). The figure below shows the folder and the mentioned system files).



Detected peak frequencies by the peak detection algorithm are stored in the file PeakFrequencies.txt shown below:



Examples of the content of the PeakFrequencies.txt file depending on quartz sensor type @5MHz (above: 5 detected peaks) or @10Mhz (below: 3 detected peaks)

The baseline correction is important for two main reasons:

1. the baseline correction allows the peak amplitudes to be correctly evaluated, with reference to a common base value;

2. On the other hand, the baseline estimation (by using Least Squares Polynomial Fit method) is applied in 'Measurement openQCM Q-1 device Operation Mode'

Important note: do not remove or try to modify these system files because otherwise the software may not work anymore. In any case, a backup of these files (initial setup) is present in the backup folder.

SOFTWARE

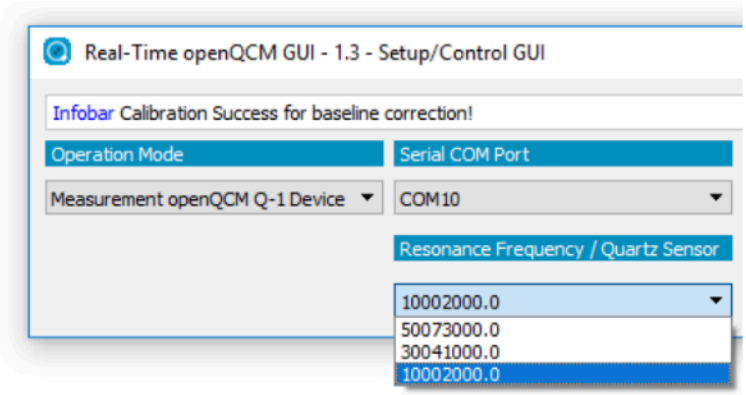
Measurements

How to setup realtime data acquisition

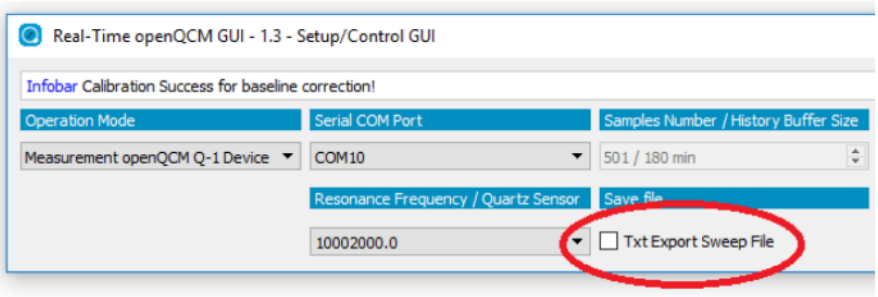
In order to start a new acquisition and measurement procedure of frequency and dissipation follow the steps below:

1. Select the working frequency

Select the working frequency, that is fundamental frequency or overtones, from the drop-down menu #3 (Please note that the resonance frequencies are displayed in descending values).

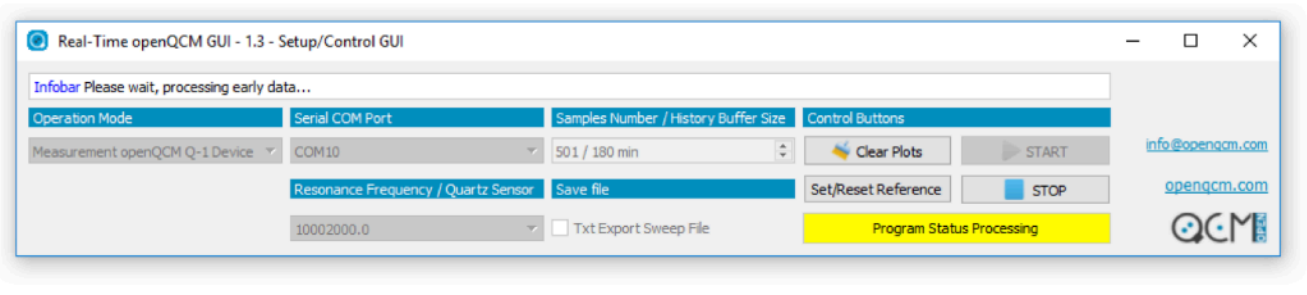


(Optional) Flag Txt Export Sweep File #4 if you want to store raw data corresponding to each sweep

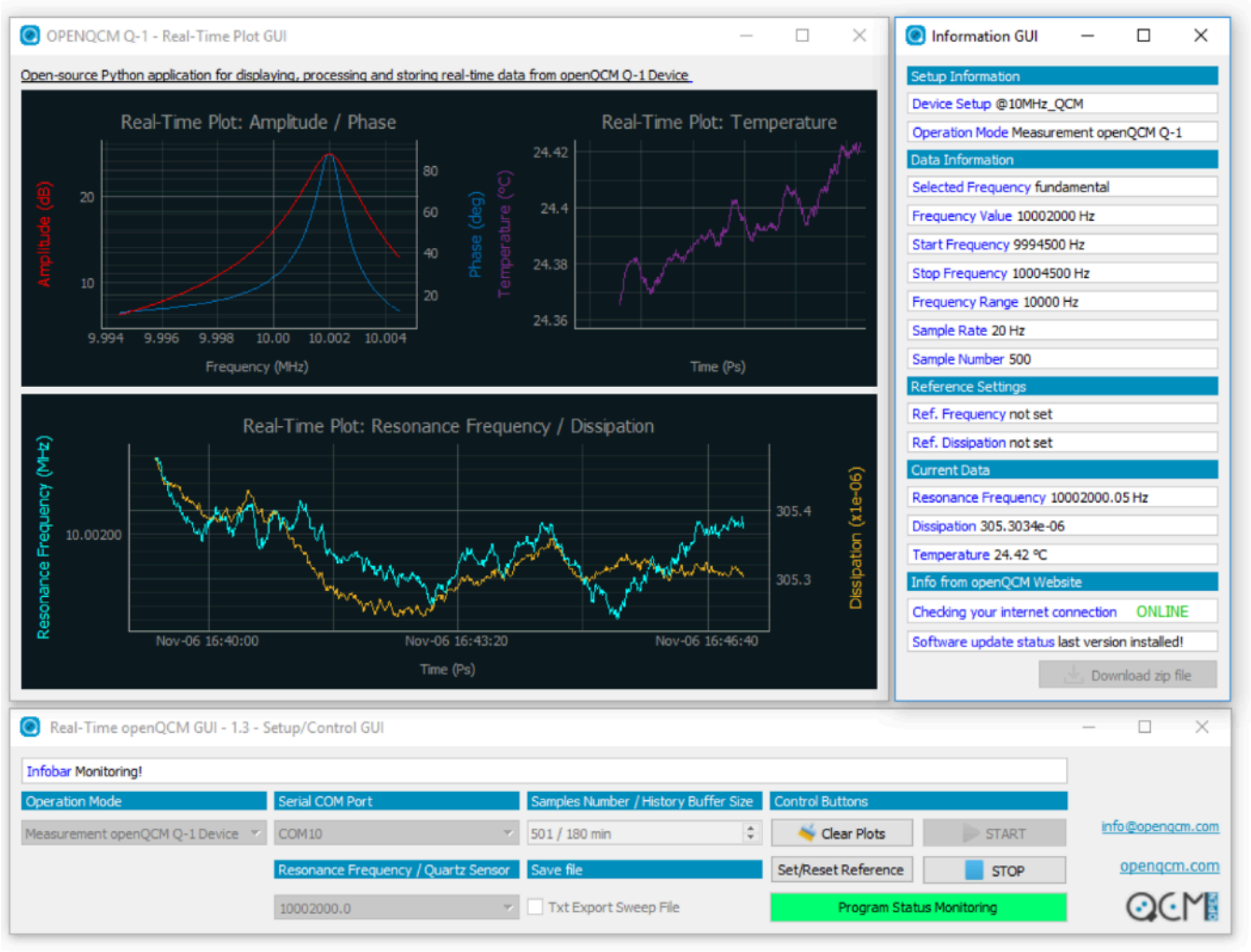


2. Select the working frequency

Press the START button to start a new data acquisition – measurement. You can read in the Infobar or in the anaconda prompt: “Please wait, processing early data...” (you need to wait about 30 sec). The Program Status indicator has turned yellow (see figure)

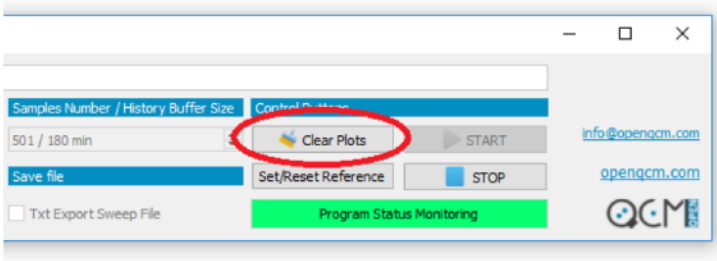


When the waiting time expires, the measurement starts. You can read in the Infobar: “Measuring!”. The Program Status indicator has turned green (see figure). “Current Data” in the Information GUI shows current value of frequency, dissipation and temperature in real-time.



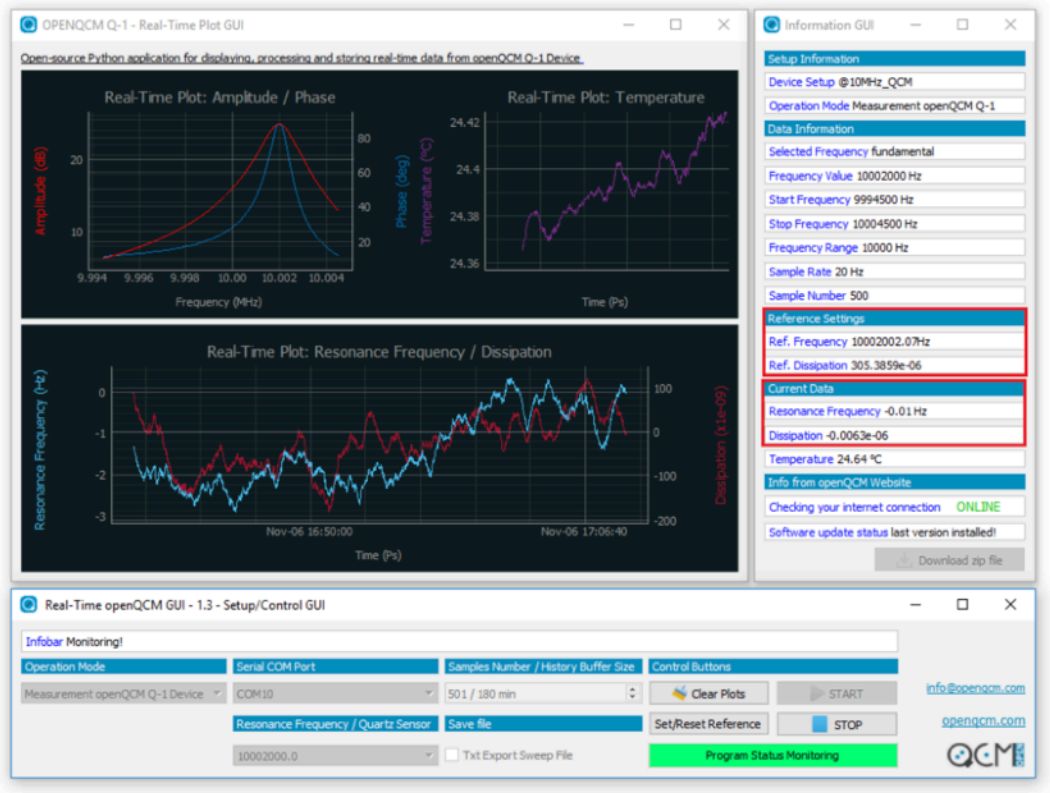
3. Clear plot

If you press Clear plots button you can clear all real-time plots in the Real-Time Plot GUI (works only in Measurement openQCM Q-1 device operation mode).



4. Set/Reference

If you press Set/Reset Reference button you can set/Reset a zero line reference corresponding to the current data plotted in the Real-Time Plot GUI (works only in Measurement openQCM Q-1 device operation mode).

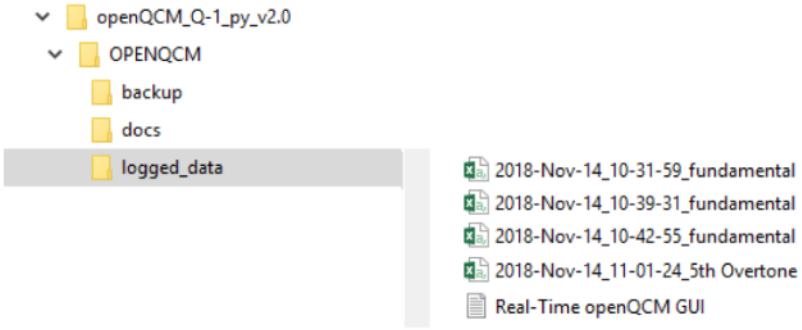


5. Data Storage

Frequency, dissipation and temperature real-time data are automatically stored each time a new acquisition is initiate. Data file is stored in the following directory

```
...\openQCM_Q1_py_v2.1\OPENQCM\logged_data
```

as shown below :



Data file extension is .csv. A typical saved file has the name as shown below: [Timestamp]_[overtone name].csv In this file (see the example in figure) there are 5 columns :

- Date, Time, the date and the time at which the event is occurred and recorded;
- Relative_time, the relative time (referred to start) in seconds at which the event is occurred;
- Resonance_Frequency data - Dissipation data

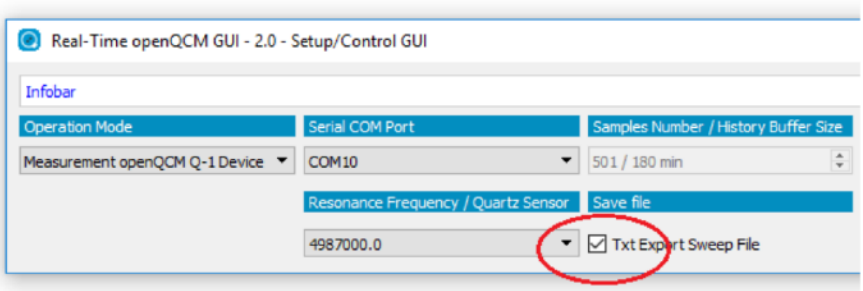
	A	B	C	D	E	F	G
1	Date	Time	Relative_time	Temperature	Resonance_Frequency	Dissipation	
2	11/15/2018	17:10:08	0	20.92	10002756.8	0.000302691	
3	11/15/2018	17:10:09	0.71	20.92	10002756.79	0.000302696	
4	11/15/2018	17:10:10	1.38	20.92	10002756.8	0.0003027	
5	11/15/2018	17:10:11	2.02	20.92	10002756.8	0.000302702	
6	11/15/2018	17:10:11	2.73	20.92	10002756.8	0.000302706	
7	11/15/2018	17:10:12	3.41	20.92	10002756.8	0.000302707	
8	11/15/2018	17:10:13	4.08	20.93	10002756.77	0.000302707	
9	11/15/2018	17:10:13	4.74	20.93	10002756.78	0.000302708	
10	11/15/2018	17:10:14	5.44	20.93	10002756.79	0.000302708	
11	11/15/2018	17:10:15	6.13	20.93	10002756.77	0.000302708	
12	11/15/2018	17:10:15	6.81	20.93	10002756.77	0.000302704	
13	11/15/2018	17:10:16	7.47	20.93	10002756.77	0.000302703	
14	11/15/2018	17:10:17	8.19	20.93	10002756.77	0.000302704	
15	11/15/2018	17:10:17	8.87	20.94	10002756.69	0.000302701	
16	11/15/2018	17:10:18	9.55	20.94	10002756.69	0.000302704	
17	11/15/2018	17:10:19	10.21	20.94	10002756.71	0.000302703	
18	11/15/2018	17:10:19	10.85	20.94	10002756.68	0.000302701	
19	11/15/2018	17:10:20	11.53	20.94	10002756.7	0.000302704	
20	11/15/2018	17:10:21	12.26	20.94	10002756.71	0.000302703	
21	11/15/2018	17:10:21	12.95	20.94	10002756.73	0.000302707	
22							
23							

2018-Nov-15_17-04-38_fundamenta

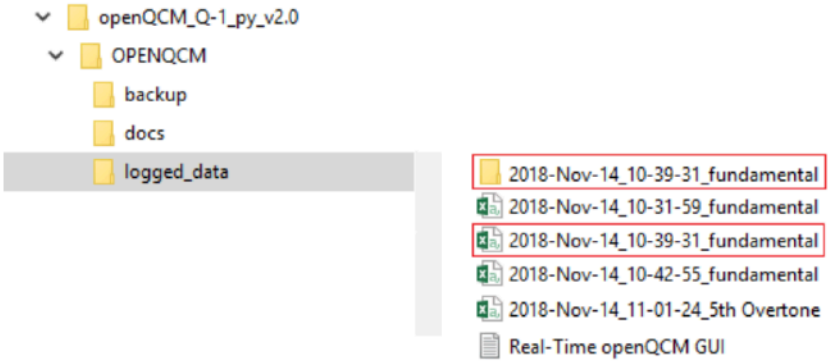
Pronto

Saved data file example (opened with Microsoft Excel)

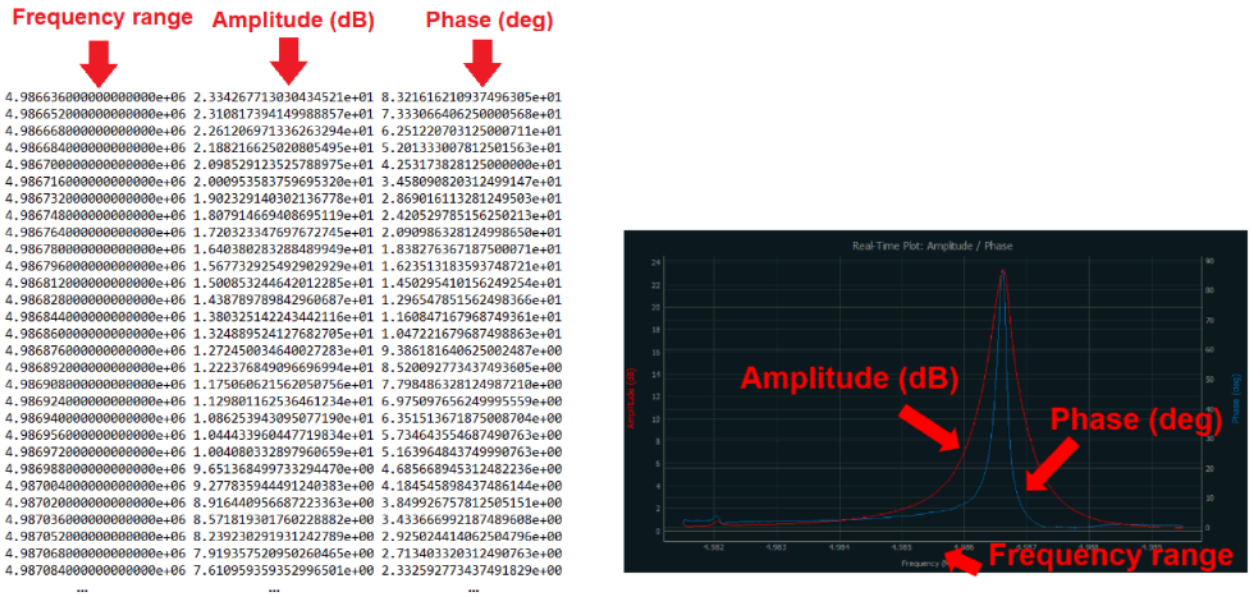
If the checkbox Txt Export Sweep File is selected you can store raw data corresponding to each sweep.



Data file is stored in the following directory as shown in figures below:



Data file extension is .txt. A typical saved file has the name as shown below: sweep_[overtone name]_[sweep number].txt In this file (see the example in figure) there are 3 columns (according to Real-Time plot GUI): - Frequency range of selected overtone; - Amplitude values in dB; - Phase values in deg.



An example of saved sweep file (.txt) and the real-time plot of amplitude and phase

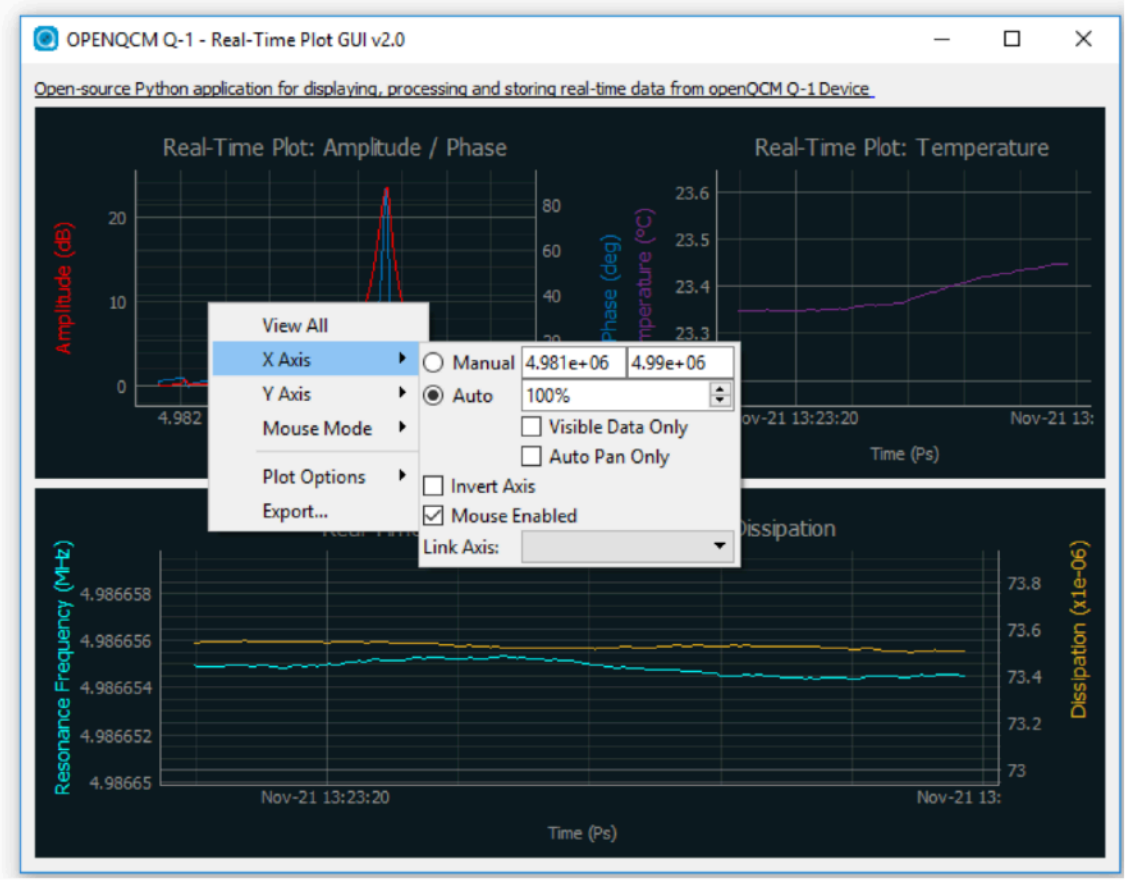
SOFTWARE

Real-time plots

Options and interactive controls

Real-time plot areas are based on PyQtGraph, a graphics and user interface library for Python that provides functionality commonly required in engineering and science applications. Its primary goals are 1) to provide fast, interactive graphics for displaying data (plots, video, etc.) and 2) to provide tools to aid in rapid application development.

A series of options are available by right-clicking to open a context menu.



- **View all** causes the view to zoom once such that all data is visible.
- **X** and **Y axis** menus have the following options:
  - **Manual** allows the range spanned by the axis to be manually fixed at the specified values.
  - **Auto** causes the view to automatically scale to fit any new data within the view. This is particularly useful for plots that are continuously updating with new data. The numerical value indicates the

percentile of the data that will be visible, allowing automatic scaling to exclude outliers. Note that dragging the view (as described above) will cause automatic scaling to be temporarily disabled.

- **Visible data only** is used when only a portion of the data is visible in the view (for example, when looking at a short section of a much longer plot). In this case, the automatic scaling only considers that part of the data which lies inside the view.

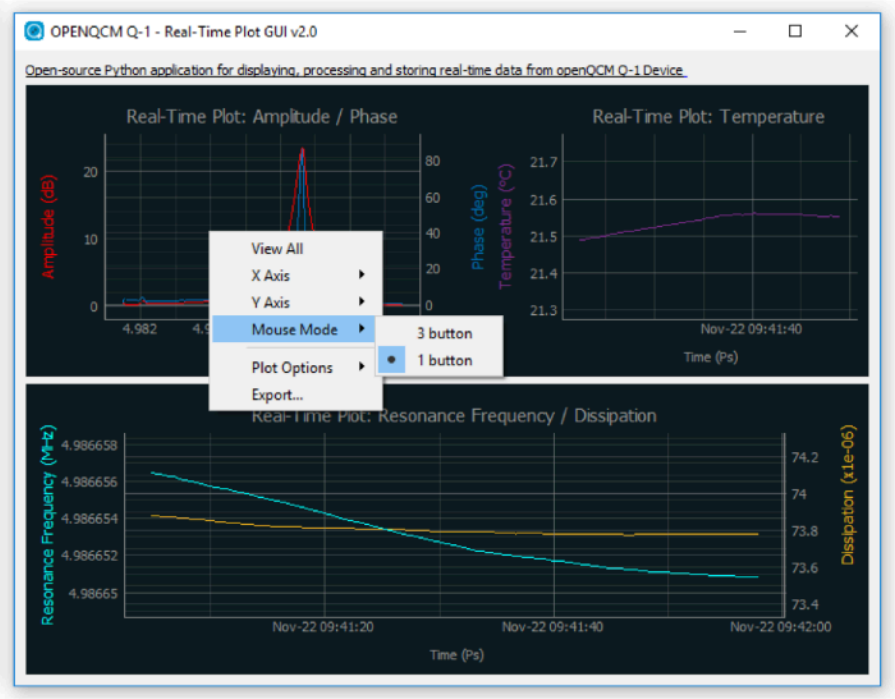
- **Auto pan only** causes the auto-scaling mechanism to only re-center on the average value of the data, without rescaling. This is useful for continuously updating plots where it is desirable to be able to easily compare the amplitude of a signal as the data updates.

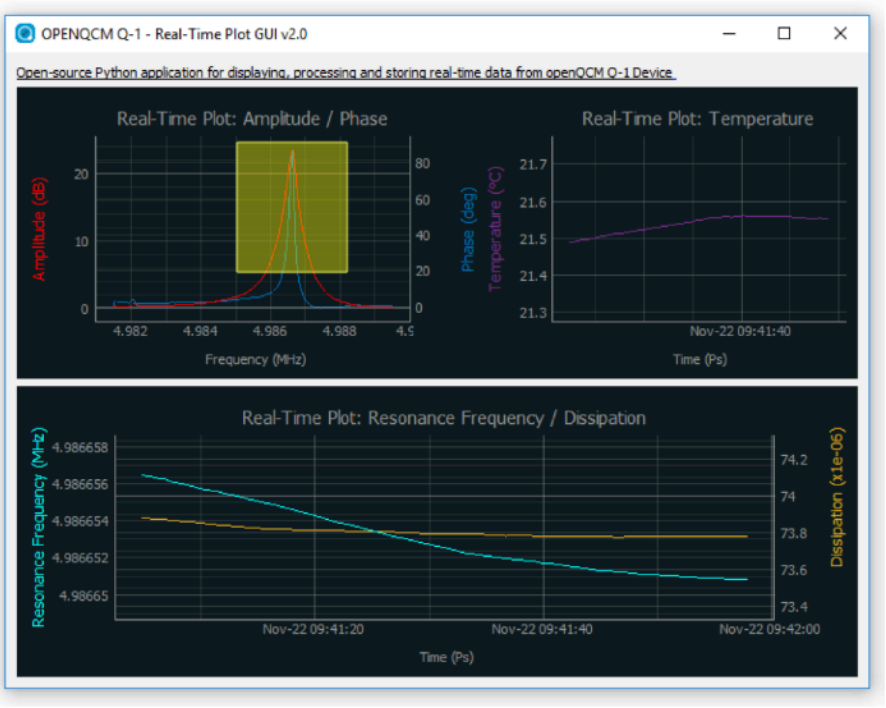
- **Mouse enabled** specifies whether any of the mouse dragging operations described above will affect the given axis. This is typically used to lock one axis while allowing the other to be manipulated with the mouse.

- **Invert axis** indicates whether the direction of increasing value should be reversed from the default.

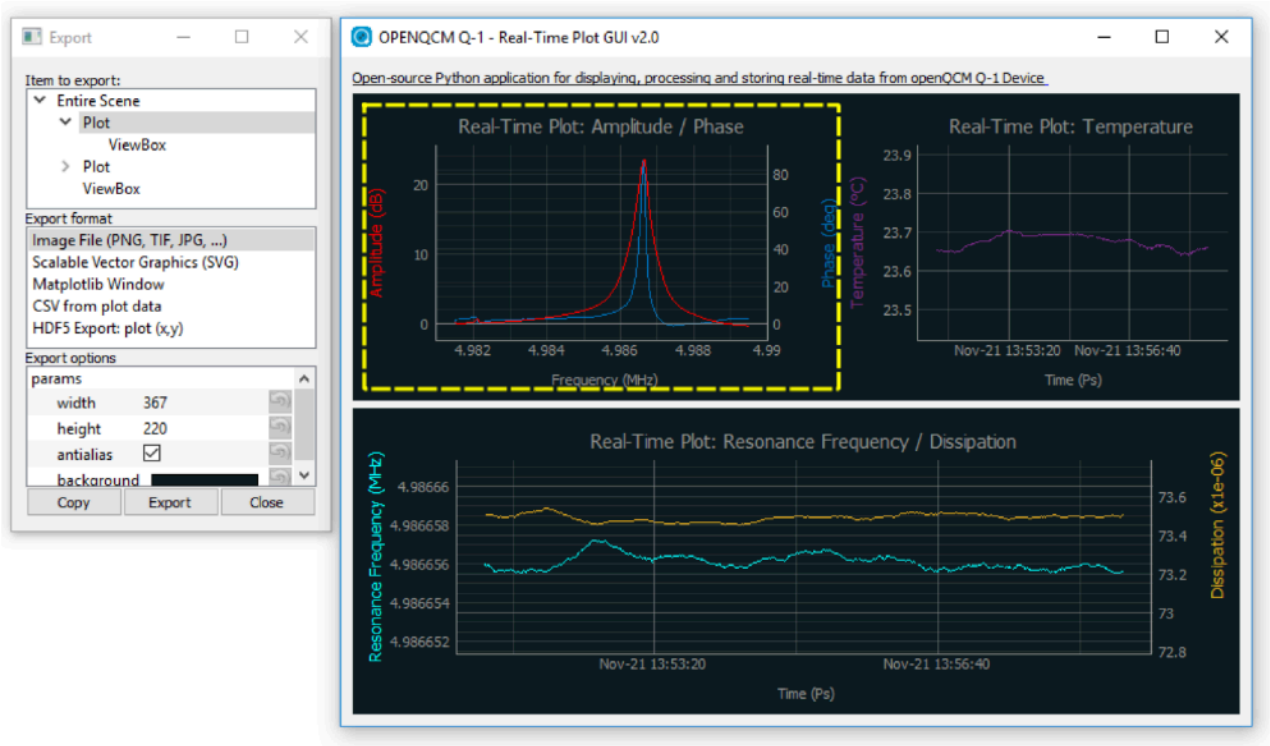
- **Link axis** allows the ranges of two plots to be linked together such that the data they display may be compared with the same scaling and alignment

- **Mouse mode** allows selection between the default 3-button mouse mode (described above) and a simplified interaction mode that is more natural for one-button mice. In this mode, a scrolling motion (typically a two-finger swipe) will zoom the plot exactly as the mouse wheel, while dragging the mouse will draw a rectangular area to be zoomed.





- **Export** causes an export dialog to be displayed which allows the contents of the graphics view to be exported to various file formats. For generating publication graphics, it is recommended to export to SVG, then further modify the figure with a vector graphics editor such as Inkscape or Illustrator. (You can select: Entire Scene, Plot or ViewBox as in the example in the figure below)



Export Format The following options currently work:

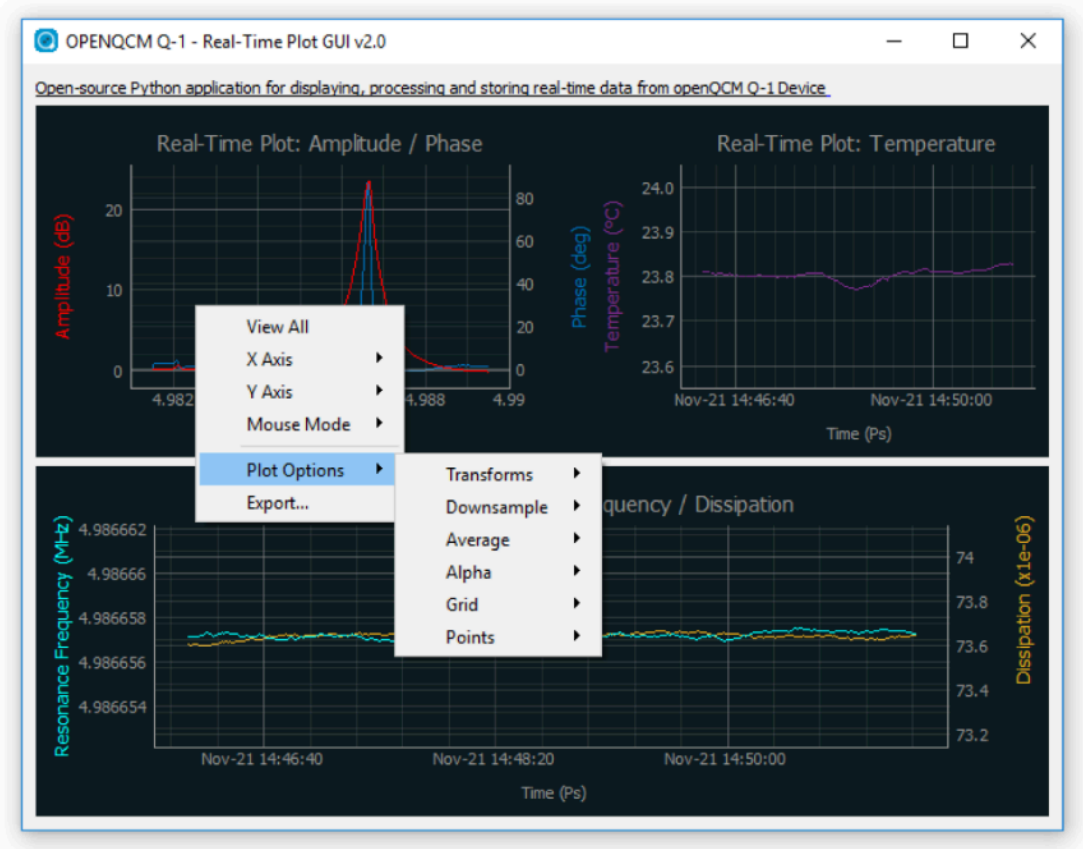
- Scalable Vector Graphics (SVG)
- Graphics exported as SVG. - CSV from plot data
- Exports plotted data as CSV.
- HDF5 export
- Image File (PNG, TIF, JPG...)Plot context menus

Graphics views that contain plot data typically include an extra Plot options context menu with features related to plotting. The following options currently work:

- Alpha sets the opacity of the plots
- Grid shows x/y grid

while the following other options are being implemented, so please don't select them.

- Transform (under construction)
- Downsample (under construction)
- Average (under construction)



Techs

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 and Dissipation
Measurement mode	Single overtones (up to 9th overtone for 5 MHz quartz sensors)
Minimum Sampling time	~ 650 ms for each harmonic

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): 143.1 x 66.8 x 26 mm
Weight	50 g

Microprocessor Embedded

Teensy 3.6 based on ARM Cortex-M4	
Programming language	C++ arduino - language based code

Software

Real - time frequency and dissipation monitoring and data storage	
Programming language	Python code
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

openQCM is licensed under a Creative Commons

openQCM is a brand of Novaetech S.r.l.
Novaetech S.r.l. provides the device described in this document under the following conditions:

openQCM device is released as a scientific open source instrument, 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. Users handling the device must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products for general consumer use. This open source instrument does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives. The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies Novaetech S.r.l. from all claims arising from the handling or use of the goods. Due to the open source construction and nature of the device, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Novaetech S.r.l. currently deals with a variety of customers for products, and therefore our arrangement with the user is not exclusive.

Novaetech S.r.l. assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.

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

openQCM device is released as a scientific open source instrument, 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. It should generate, use, and radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference

Final Notes

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