OPENQCM NEXT
QUARTZ CRYSTAL MICROBALANCE

SOFTWARE USER GUIDE
VERSION 0.1.4

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.

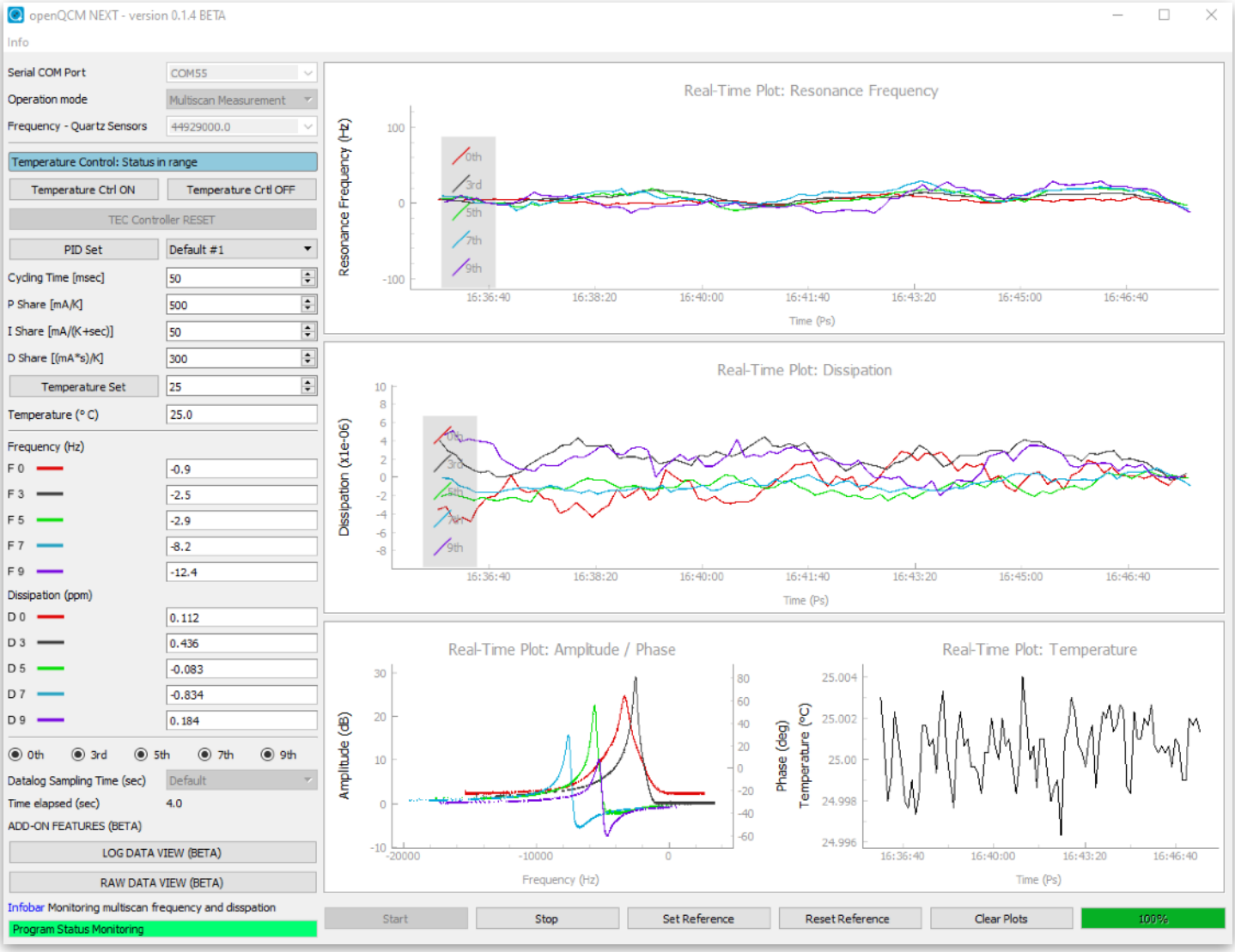
openQCM by Novaetech Srl
Piazza Bartolo Longo, 28
80045 Pompei (NA)
Italy
https://openqcm.com

Date:
Software Version: 0.1.4
User Guide Version: 1.0

Summary

openQCM NEXT Software Application

The openQCM Next software user interface able to exploit all the functionalities of the device. Developed in Python programming language to ensure open source approach in scientific application

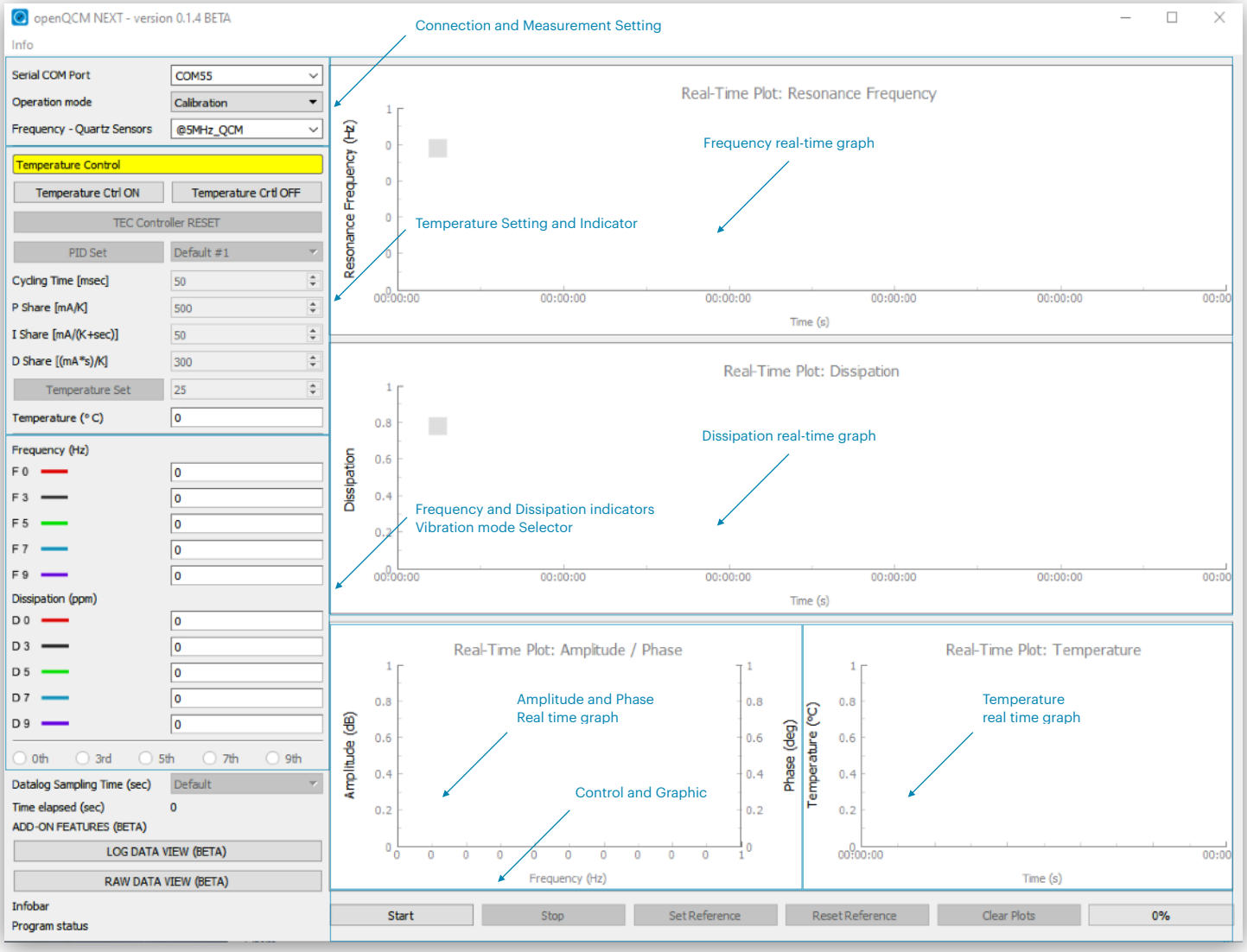


openQCM NEXT python software application version 0.1.4

The opeQCM NEXT software application is developed in Python programming language, which is open source, object - oriented and suited for scientific application. Python makes the software program easy to modify and develop for custom application.

The new opeQCM NEXT software is able to exploit all the main functionalities of the device. Real time monitoring of frequency and dissipation on the fundamental mode and overtone harmonics. It is possible to acquire almost simultaneously 5 sweep signals and elaborate the frequency and dissipation measurement in roughly 7 seconds. In addition, the application allows to control and monitor the sensor module temperature in real time.

Software GUI General Description



Connection and Measurement Setting

Serial COM Port	Drop-down menu for selecting the COM port connected to the openQCM Next device
Operation Mode	Calibration: record the quartz resonator calibration signal for resonance peak detection
	Single Measurement: real time monitoring of frequency and dissipation on a single frequency of the quartz resonator spectrum
	Multiscan Measurement: real time monitoring of frequency and dissipation on fundamental and overtone harmonics of the quartz resonator
Frequency / Quartz Resonators	Calibration operation mode: Select 10 MHz or 5 MHz quartz resonator fundamental frequency
	Single Measurement mode: Select the quartz resonator frequency to monitor

Temperature setting and indicator

Temperature Ctrl ON	Enable the temperature control
Temperature Ctrl OFF	Disable the temperature control
TEC Controller Reset	Press the button to reset the temperature controller after an error status event. Disabled by default
PID Set	Press the button to change the PID parameters of the TEC control
P Share	Proportional parameter. Default value 1000 mA/K Range: (0 to 100000 mA/K)
I Share	Intergral parameter. Default value 200 mA/(K*sec) Range: (0 to 100000 mA/(K+sec))
D Share	Differential parameter. Default value 100 (mA*s)/K Range: (0 to 100000 (mA*s)/K)
Temperature Set	Press the button to change in real time the set temperature Default value 25° C Temperature Range: (5 to 45° C)
Temperature (°C)	Current value of the temperatrure

Temperature Real Time Graph

Real Time Plot: Temperature	Real time plot of temperature data measured in °C

Amplitude and Phase Real Time Graph

Real Time Plot: Amplitude / Phase	Calibration: plot of amplitude and phase signals over all frequencies ranging from 1 MHz to 51 MHz
	Single Measurement: plot of amplitude and phase signals around the selected single resonance frequency (fundamental or harmonic overtones)
	Multiscan Measurement: plot of amplitude of all resonance frequencies detected, fundamental and harmonic overtones

Frequency and Dissipation Real Time Graph

Real-Time Plot: Resonance Frequency Real-Time Plot: Dissipation	Single Measurement: real-time plot of frequency and dissipation of selected single vibration mode (fundamental or harmonic overtones)
	Multiscan Measurement: real-time plot of frequency and dissipation for all vibration modes detected, fundamental and harmonic overtones

Control and graphic buttons

Start	Start a session of measurement, applies for each operation modes
Stop	Stop a session of measurement, applies for single and multiscan operation modes
Set Reference	Press the button to set the current value of frequency and dissipation as the reference value to measure variations, applies for single and multiscan operation modes
Reset Reference	Press the button to reset the current value of frequency and dissipation to actual values, applies for single and multiscan operation modes
Clear Plots	Clear the history of each real time graph
Progress bar	Calibration: indicator showing the progress of the frequency scan over all frequencies ranging from 1 MHz to 51 MHz
	Single and Multiscan Measurement: indicator showing the accumulation of initial raw data before frequency and dissipation data processing

Frequency and Dissipation Indicator

Frequency and Dissipation Indicator	Single Measurement: real time indicator of current value of frequency (Hz) and dissipation (ppm) of selected single vibration mode (fundamental or harmonic overtones)
	Multiscan Measurement: real time indicator of current values of frequency (Hz) and dissipation (ppm) for all vibration modes detected, fundamental and harmonic overtones

Vibration Mode Selector

Fundamental and harmonic overtones	Multiscan Measurement: select radio buttons for showing frequency, dissipation and amplitude real time plot of the corresponding mode of vibration

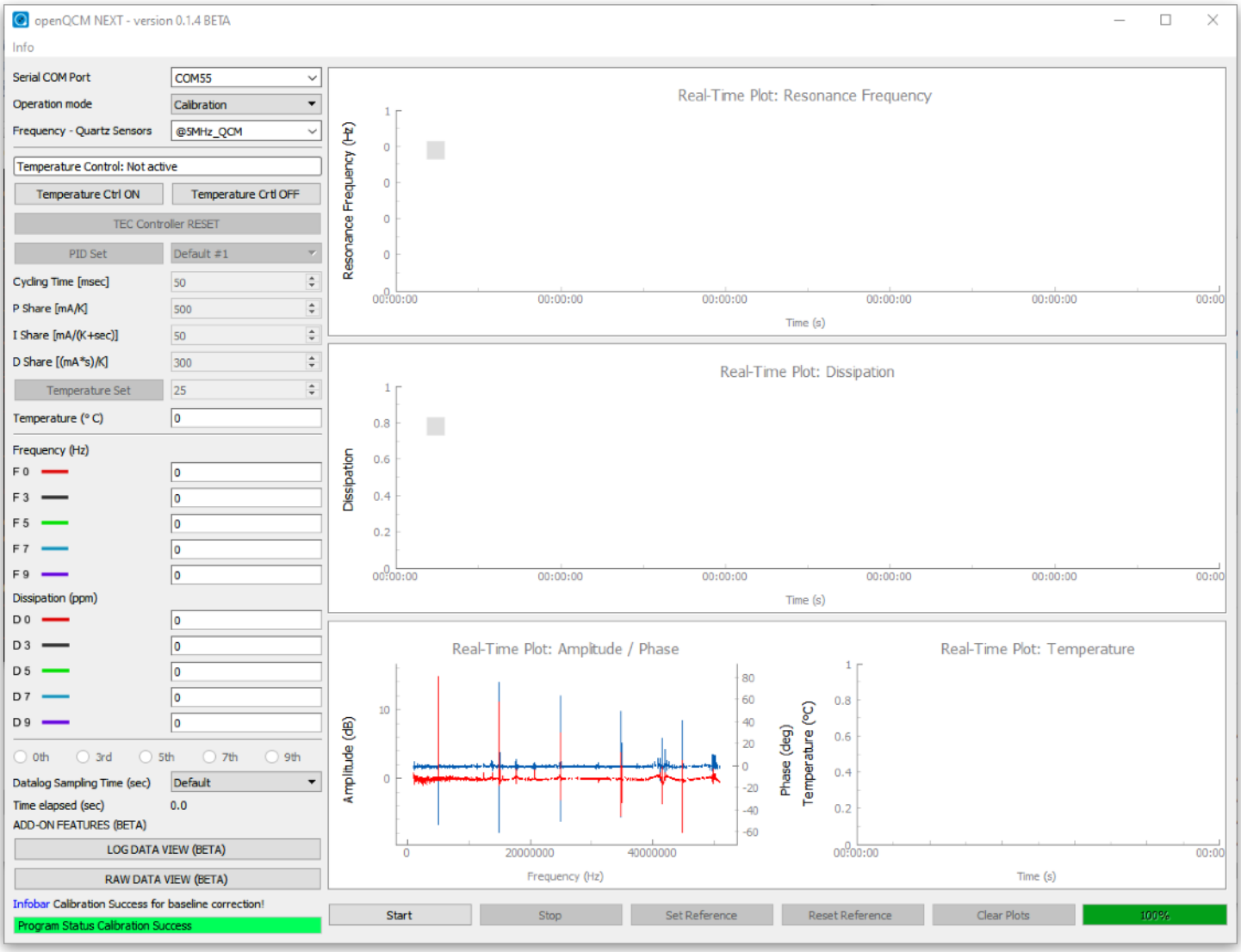
Datalog Sampling Time

Datalog Sampling time	Multiscan Measurement: select the datalog sampling time using the drop - down menu. Default value is the hardware minimum sampling time, 7 seconds
Time elapsed	Time elapsed between consecutive datalog samples

Add - On Features (Beta)

LOG DATA VIEW	Multiscan Measurement: Application for viewing and processing the data acquired during the current session of measurement.
RAW DATA VIEW	Multiscan Measurement: Plot of current sweep signals for each mode of vibration, showing raw data, filtered data and frequency points for resonance and dissipation calculation

Calibration Mode of Measurement



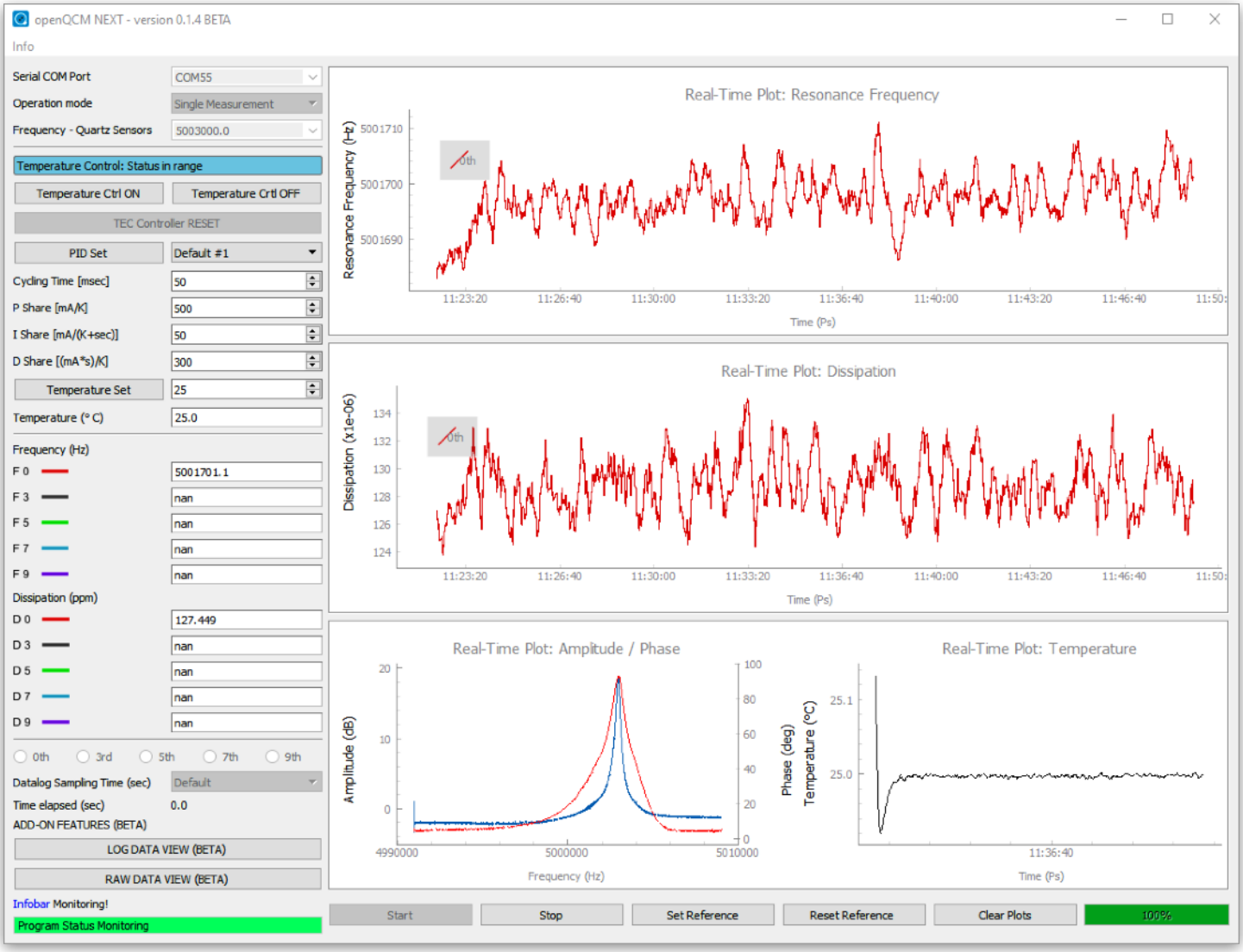
Calibration measurement of a 5 MHz quartz resonator in contact with air. The Amplitude real time graph shows the detection of the resonance frequencies up to the 9th overtone

The Calibration mode of measurement perform a frequency sweep over all the available range from 1 MHz to 51 MHz. It is acquired the quartz resonator amplitude and phase spectrum. The main goal is to detect the resonance frequencies, fundamental mode and harmonic overtones, of the quartz resonators. It is also necessary to remove the baseline signal in the wide frequency range, for frequency and dissipation post-processing.

It is necessary to select the fundamental mode of the quartz resonator under test, using Frequency / Quartz Resonators drop down menu in order to facilitate the resonance peak detection algorithm.

The calibration measurement must be started each time the quartz resonator or sample in contact with quartz resonator is changed.

Single Mode of Measurement



Single mode measurement of a 5 MHz quartz resonator in contact with air at fundamental mode of vibration, with active temperature control set at T = 25.0 °C

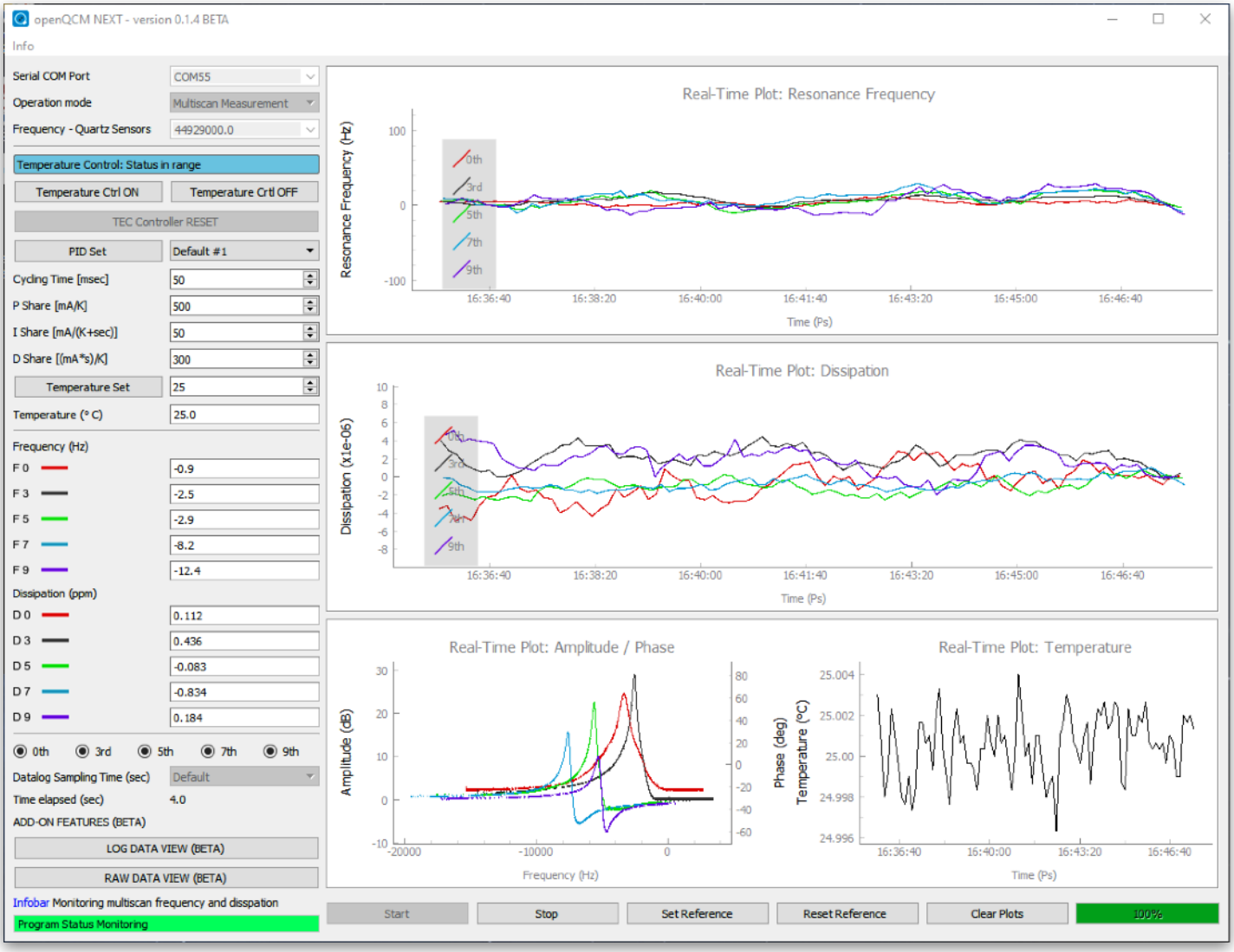
The Single mode of measurement perform a frequency sweep around a selected single vibration mode (fundamental or harmonic overtones), and retrieves in real - time the frequency and dissipation data.

The vibration mode is selected using Frequency / Quartz Resonators drop down menu.

The thermal control can be activated on the fly by pressing the Temperature Ctrl ON. Temperature set point can be changed on the fly, by changing Temperature Set value and pressing the Temperature Set button.

A new measurement session begin by pressing the Start button.

Multiscan Mode of Measurement



Multiscan mode of measurement of a 5 MHz quartz resonator in contact with air, from fundamental to 9th overtone mode of vibration, with active temperature control set at T = 25.0 °C. Frequency and dissipation variation referred to the initial reference values

The Multiscan mode of measurement mode performs a frequency sweep around each mode of vibration fundamental and harmonic overtones one after another. It retrieves in real - time the frequency and dissipation over all harmonics almost at the same time.

The thermal control can be activated on the fly by pressing the Temperature Ctrl ON. Temperature set point can be changed on the fly, by changing Temperature Set value and pressing the Temperature Set button.

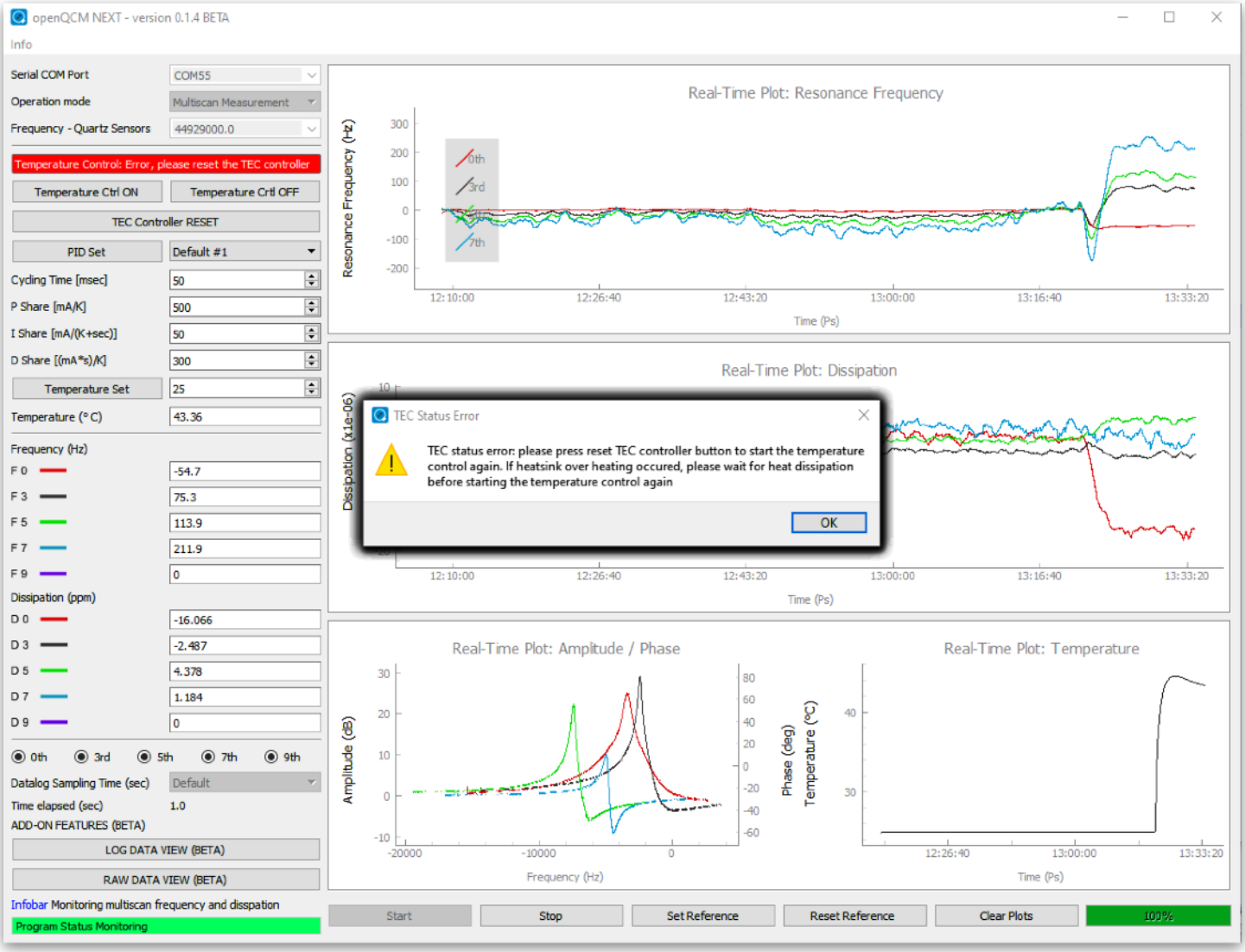
Visualisation of frequency and dissipation multi plot graph can be enhanced by pressing Set Reference button, so that the current value of frequency and dissipation is the reference value to measure variations. In addition, by selecting radio buttons vibration mode selector it is possible to visualise just the harmonics of interest.

Temperature TEC Controller

The temperature control can be activated on demand in both Single and Multiscan mode of measurement. Temperature set - point can be changed on demand in both Single and Multiscan mode of measurement. Change the Temperature control value and press the Temperature Set button to change the value of the temperature set - point

PID parameter: Proportional share, integrating share of the amplification and differential share can be changed on demand during the measurement session.

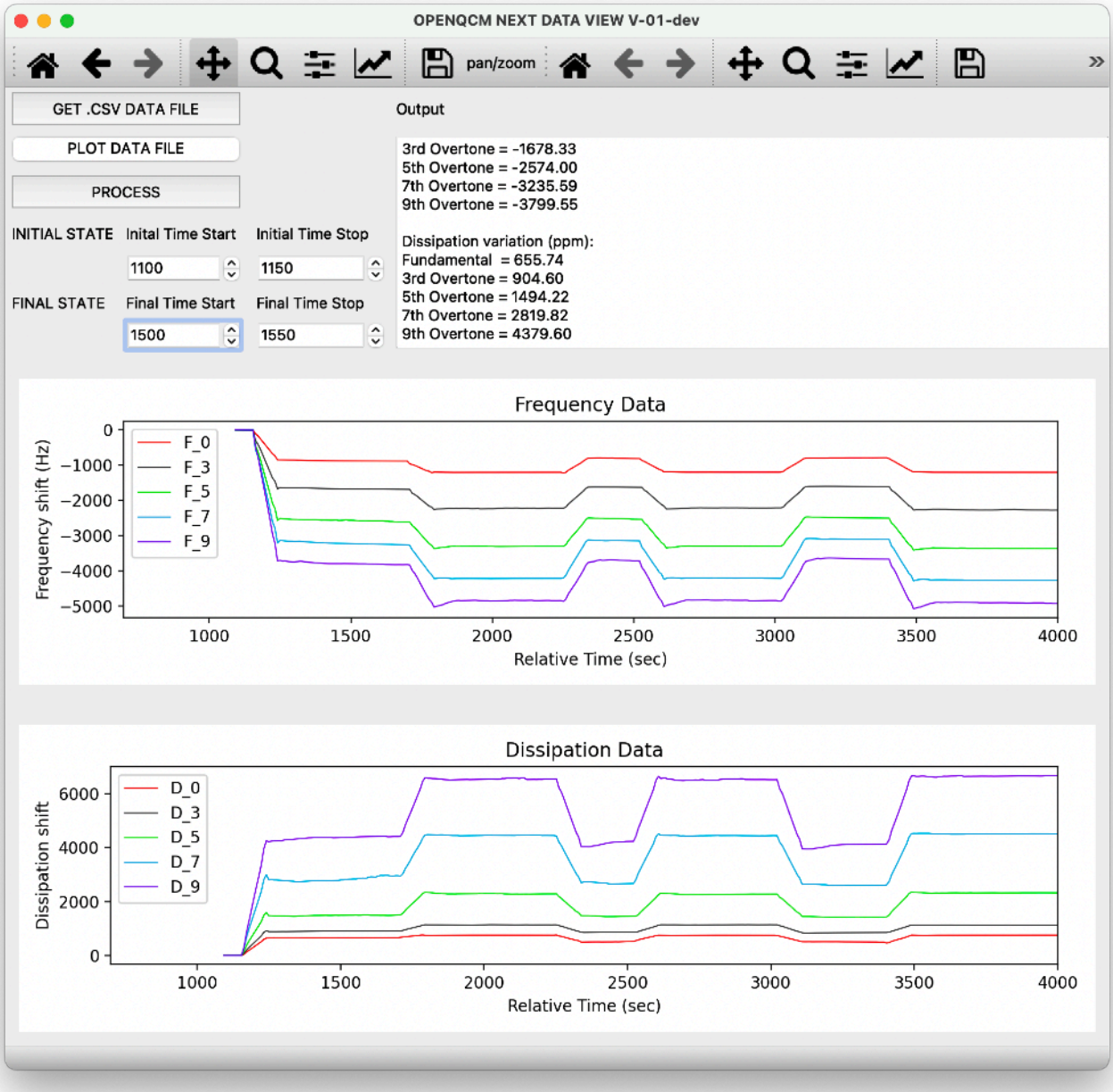
TEC Controller Reset



Pop-up window of TEC controller status error alert.

TEC status error may occur if the TEC controller is unable to get the set - point temperature. In this case a pop-up warning window will appear, press OK button to go ahead. Press the TEC Controller Reset button to reset the temperature controller after the error status event and start the temperature control again. TEC Controller Reset button is disabled by default, it is enabled only after the error status event.

Log Data View (Beta)



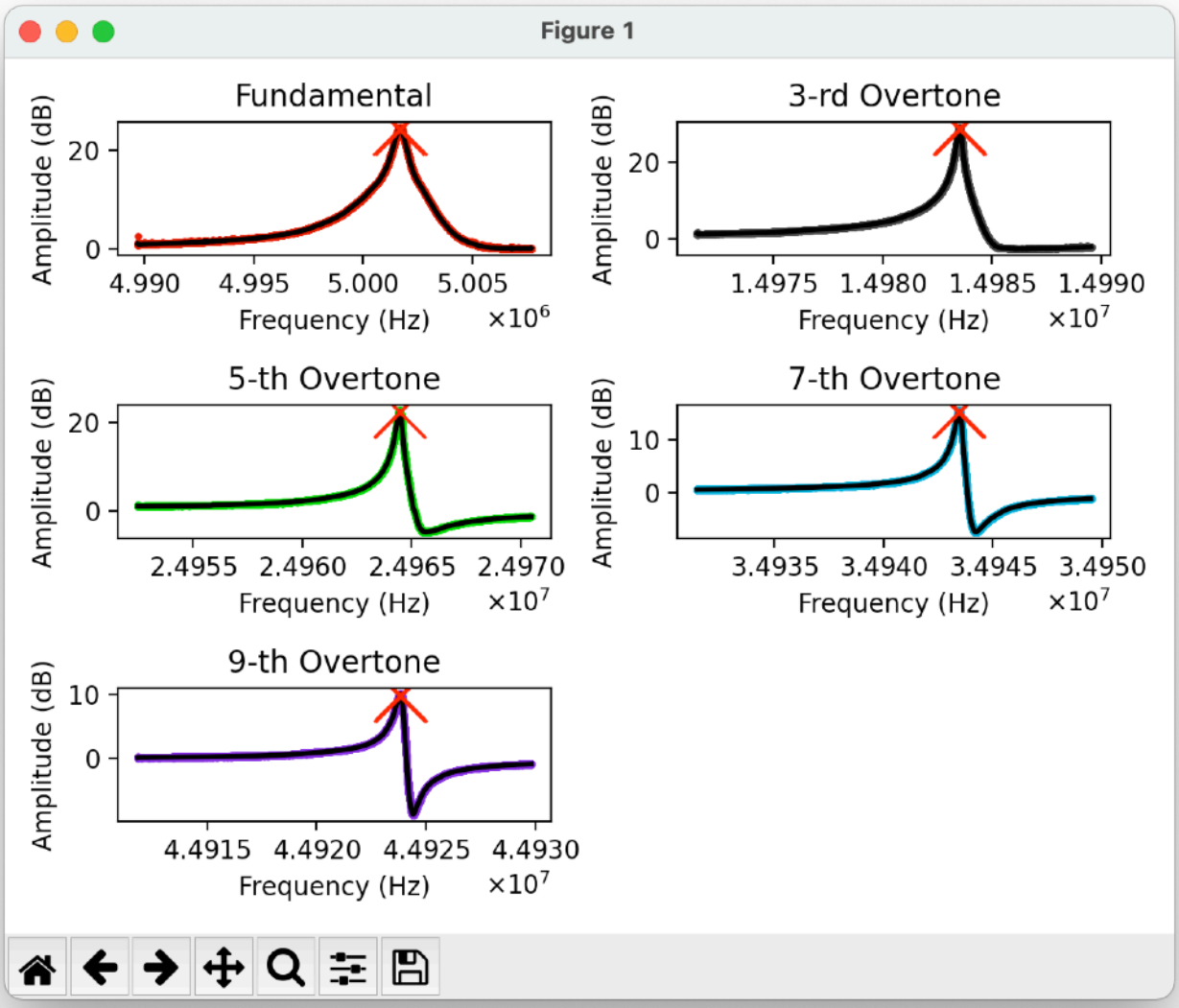
Frequency and Dissipation shift variations caused by the passage from pure air to water, and water to isopropanol, using a 5 MHz quartz for fundamental, 3rd, 5th , 7th and 9th overtone. Working temperature set at 25°C

Application for viewing and post - processing the data acquired during the current session of measurement. The application runs in parallel with the main application

Press GET .CSV DATA FILE button to select the datalog file to view. Frequency Data and Dissipation Data will be automatically plot.

Digit the initial state time frame (initial time start and initial time stop) and final time frame (final time start and final time stop), press the PROCESS button to get the frequency and dissipation variations for each overtone.

Raw Data View (Beta)



Raw sweep signals using a 5 MHz quartz for fundamental, 3rd, 5th , 7th and 9th overtone.

Plot of current sweep signals for each mode of vibration, showing raw data, filtered data and frequency points for resonance and dissipation calculation

Dots represent raw data sweep acquired and transmitted by the microcontroller. Black line is the filtered data, a combination of a Savitzky–Golay and univariate spline filtering. Red Cross correspond to the maximum of the resonance curve and bandwidth.

Installation Instructions and Usage

Windows OS stand alone application

Download the stand alone executable version developed for Windows operating system openQCM NEXT python software application version 0.1.4
The stand alone executable bundles the Python application and all its dependencies into a single package. You can run the executable software without installing a Python interpreter or any modules.

- Download the .zip compressed application files here: https://openqcm.com/shared/next/software/openQCM_Next_py_0.1.4_exe.zip
- Unzip the package and browse to directory: .../openQCM_Next_py_0.1.4_exe
- Launch the openQCM-NEXT-0.1.4.exe application shortcut

Mac OS

TODO

Linux OS

TODO

Python source code

OpenQCM Next python source code is intended for users that wants to modify and develop the original source code. openQCM is an open science hardware device and we encourage and support community participation in device and software development. Please visit the openQCM Next software webpage for more info https://openqcm.com/openqcm-next-software

Download openQCM Next Python source code version 0.1.4 here:
https://openqcm.com/shared/next/software/openQCM_Next_py_0.1.4_source.zip

Windows OS and Mac OS python installation

- Download and install Anaconda3 for Python 3.7 version Anaconda3-5.3.0 https://www.anaconda.com/download/
- Open Anaconda3 prompt (Windows) or terminal (macOS) and install - upgrade Python packages, typing the command:
  ```
  conda install pyqtgraph pyserial
  ```

Linux OS python installation

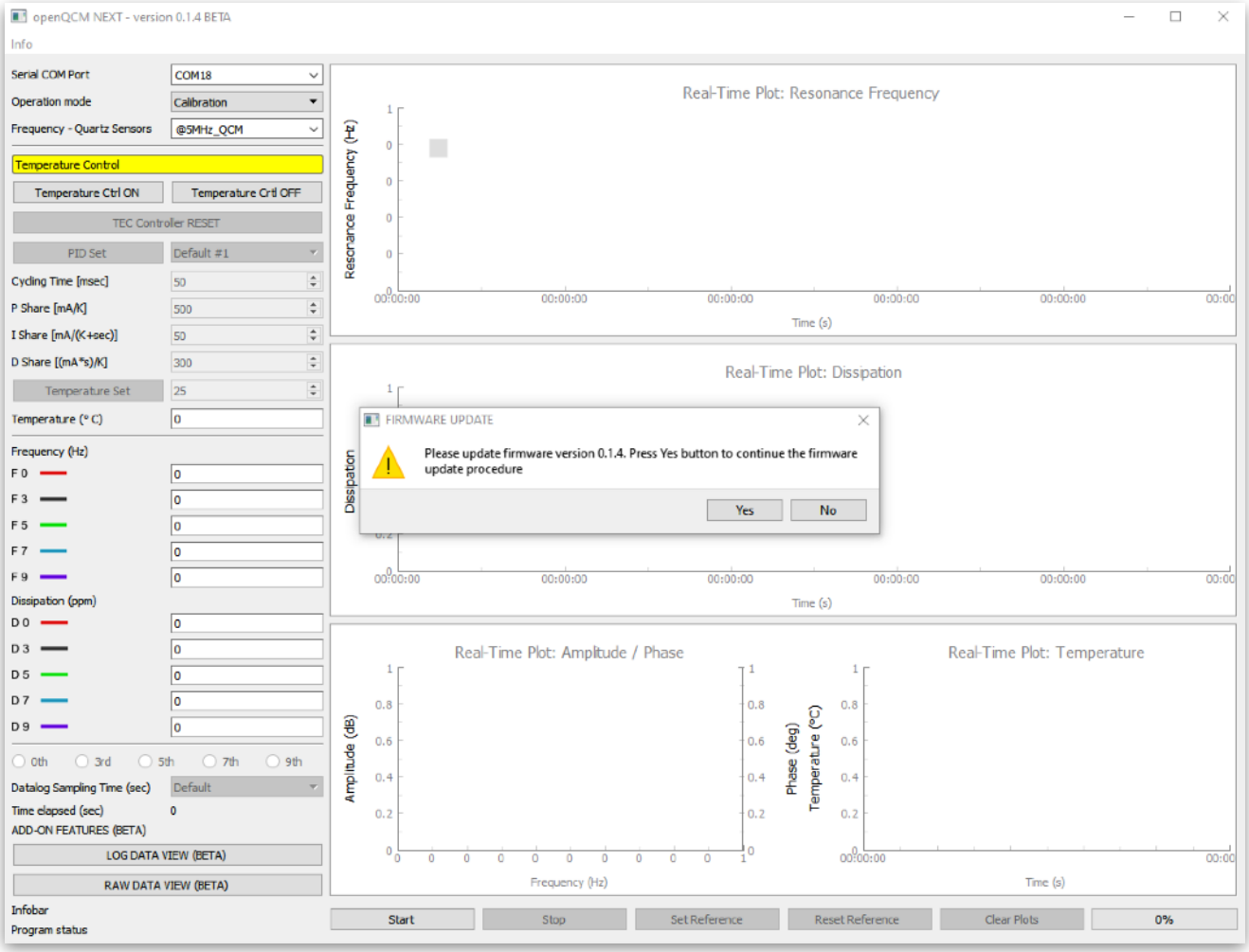
- Download and install Anaconda3 for Python 3.7 version Anaconda3-5.3.0 https://www.anaconda.com/download/
- Type the command below by replacing username with that of your pc to change permission of Anaconda3:
  ```
  sudo chown -R username:username /home/username/anaconda3
  ```
- Open Anaconda3 terminal and install - upgrade Python packages, typing the command:
  ```
  conda install pyqtgraph pyserial
  ```
- Set permission on serial port
  ```
  sudo usermod -a -G uucp username
  sudo usermod -a -G dialout username
  ```
- Logout and Login

Usage

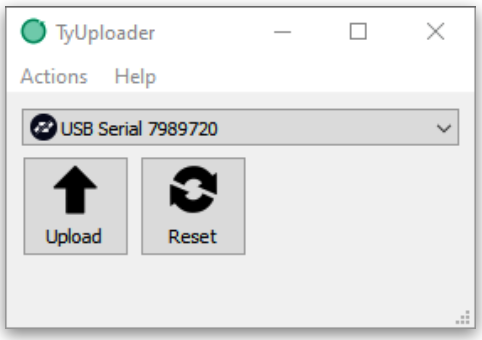
- Launch Anaconda3 prompt depending on your operating system
- Browse to the openQCM Next Python source code main directory ...\openQCM_Next_py_0.1.4_source\OPENQCM\openQCM
- Launch the python application main GUI by typing the command
  ```
  python –m openQCM
  ```

Firmware Update

Firmware update for openQCM Next Software version 0.1.4. Firmware update is necessary for integration and compatibility with the latest version of the openQCM Next Python software version 0.1.4.



- Launch the openQCM Next Software version 0.1.4 to check the firmware compatibility. If your openQCM Next device needs a firmware update, a pop-up window will appear at software startup
- Press Yes button to continue the firmware update procedure
- The Firmware update application will open. Press the Upload button
- Select and upload the binary file openQCM_Next_py_0.1.4_BETA_teensy.ino.TEENSY40.hex



Specifications

Microprocessor Embedded

Teensy 4.0 based on ARM Cortex-M7 at 600 MHz, Float point math unit, 64 & 32 bits 1984K Flash, 1024K RAM (512K tightly coupled) 1K EEPROM (emulated)	
Programming language	C++ arduino - language based code

Software

Real - time frequency and dissipation monitoring, temperature control and data storage	
Programming language	Python code
OS compatible	Windows, MacOS and Linux OS