BROCHURE

THE NEXT GENERATION
OF OPEN SOURCE
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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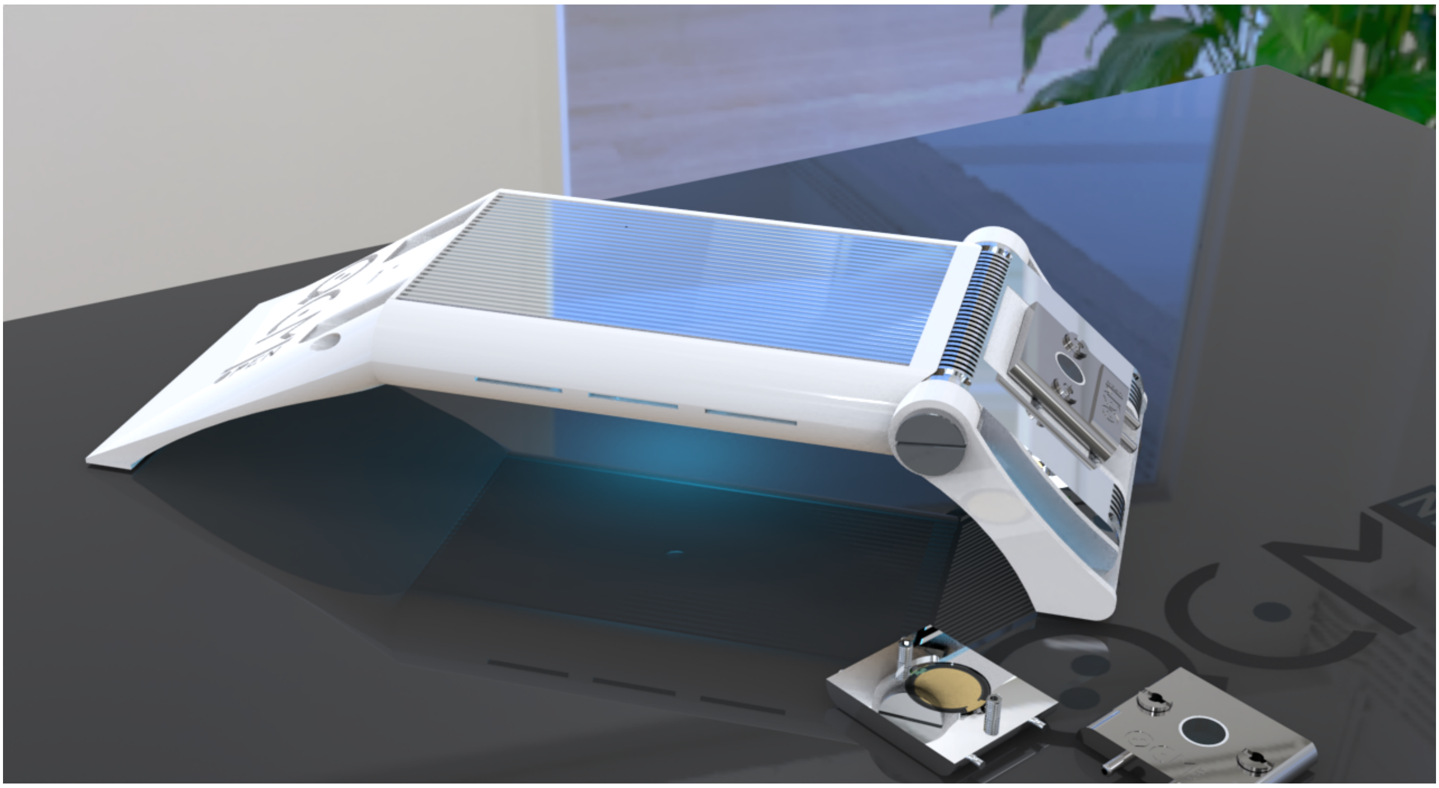
Why openQCM

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

openQCM *NEXT*

The first open Source Quartz Crystal Microbalance with dissipation monitoring, simultaneous multiple - overtones measurement and active thermal control.

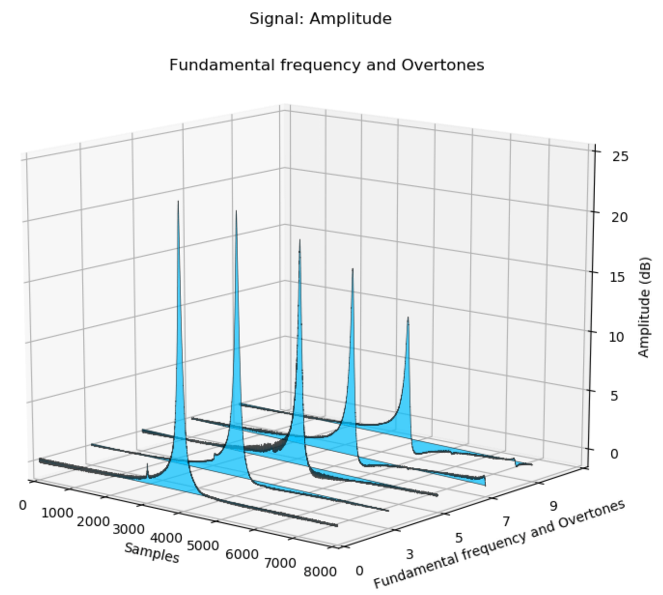


The Quartz Crystal Microbalance openQCM NEXT is a real-time analytical instrument based on a surface sensitive technology capable of monitoring phenomena at molecular scale. The NEXT is sensitive to mass and viscoelastic properties of molecular layers as they build up or change on the quartz sensor surface.

openQCM NEXT is a compact and fully scientific instrument, equipped with all the necessary accessories to be used at once.

The system has been completely re-engineered using new materials, that take into account the chemical compatibility for most of the samples used.

WORKING PRINCIPLE

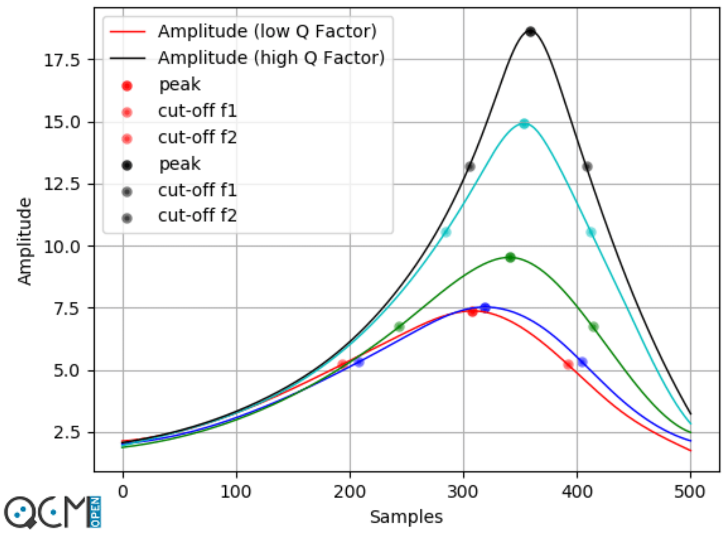


Thanks to the exponential growth in single-processor performances, it is finally possible to passively interrogate a quartz sensor on a wide range of frequencies in a time range of milliseconds.

And that's exactly what openQCM NEXT does. The main electronics is based on a network analyzer , which is capable of passively interrogates the quartz resonator by sweeping the frequency from 0 up to 50 MHz, around fundamental resonance and overtones. The electronics detect the gain-loss and phase lag resonance curves, whose properties are analysed by a dedicated algorithm. Frequency peaks and bandwidth for all detectable resonance curves are elaborated in less than 700 milliseconds. The capability of monitoring even higher harmonics is of great interest in QCM application, because it allows a more detailed characterisation of the sample especially for soft interfacial film, making the device suitable for biosensing application.

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.

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

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 the powerful Teensy 4.0 (developed by Paul Stoffregen) , that mounts a ARM Cortex-M7 brings many powerful CPU features to a true real-time microcontroller platform. So, CPU performance is many times faster than typical 32 bit microcontrollers. The high clock speed drastically increase the ADC sampling time and the resolution of the measurements.

ACTIVE THERMAL CONTROL

Onboard the main electronics is mounted a miniaturised, safe and very high accuracy complete Peltier single-module controller: MTD415 (by Thorlabs). The MTD415T is a compact and highly integrated temperature controller optimized for use in high performance thermoelectric temperature control applications. The on-chip power stage and the thermal control loop circuitry minimize external components while maintaining high efficiency. The output current is directly controlled to eliminate current surges. An adjustable TEC current limit provides the highest level of TEC protection. The MTD415T is operated from a single power supply and provides a bipolar ±1.5 A output by connecting the TEC to the output of a bipolar power stage. True bipolar operation ensures temperature control without “dead zones” or other nonlinearities at low TEC current values. These TEC controllers deliver powers up to 6 W and a maximum TEC current of ±1.5 A.

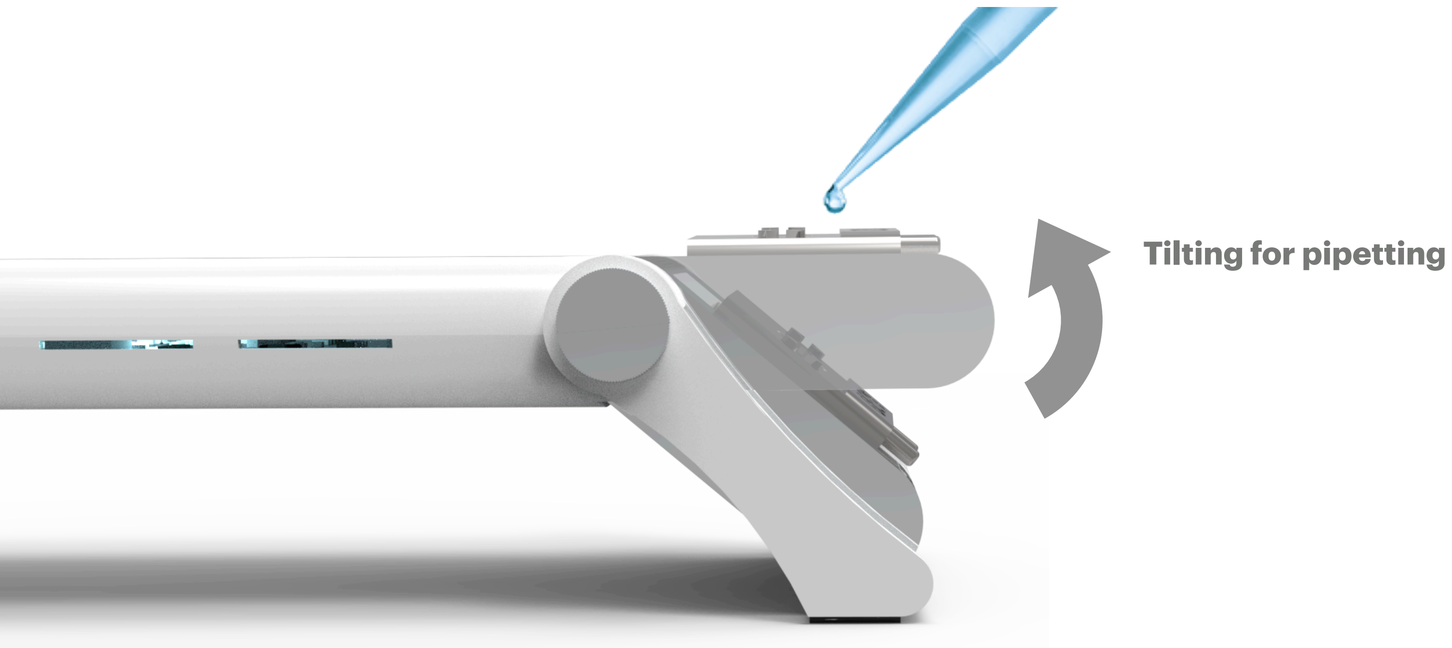
The TEC controller supports a 10 kΩ thermistor, integrated in the *Sensor Module* of openQCM NEXT.

HARDWARE

The Design

We have kept in mind thermal performances by designing each mechanical component of openQCM NEXT from scratch

OpenQCM NEXT design is the synthesis of all feedback received from the scientific community. We have come up with a characteristic bridge design, realised with the aim of maximising the thermal dissipation and electrical interferences of the electronics. The sensor module has been replaced with a custom heat sink, in which it is embedded a PTFE “slot”, housing the fluidic module. The fluidic module is the real holder of the quartz sensors, made to be a multi-purpose accessory.



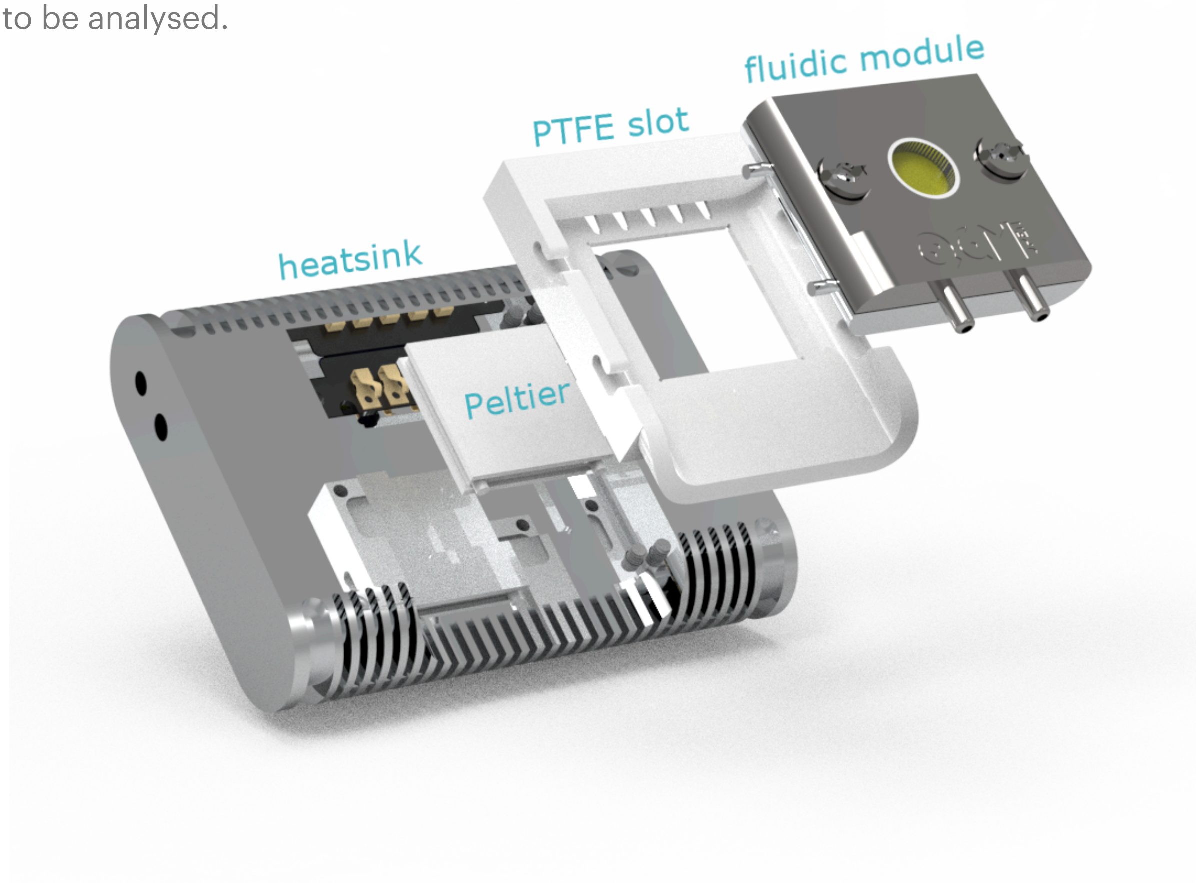
Sensor Module

A component designed to be both a heatsink and a fluidic cell holder

The Sensor Module is designed to maximise electrical ad thermal performances of openQCM NEXT. Its main body is the effective heatsink of the system. All other mechanical components are totally embedded in the main body.

We designed a PFTE slot that acts as discontinuity thermal interface between cold and hot side of the Peltier element. The slot is further designed in order to have an effective plug and play mechanical and electrical connection of the fluidic module.

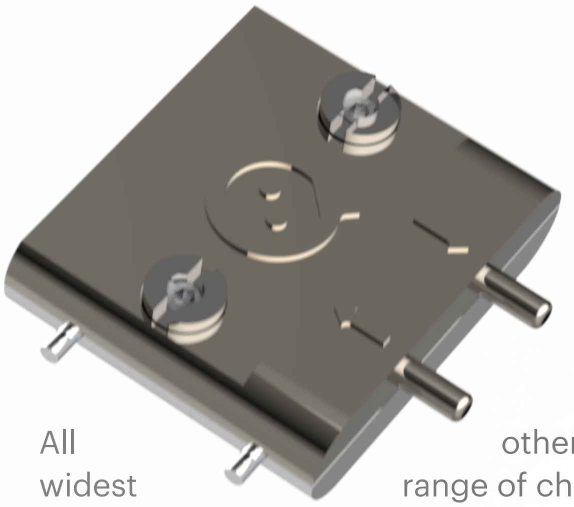
All materials were carefully selected to ensure the broadest chemical compatibility with the samples to be analysed.



	Material	Surface treatment
Heatsink	Aluminium 6063	Flash chrome plating
PTFE slot	Teflon (PTFE)	Polishing
Fluidic Module	see next paragraph	

Fluidic Module

More than a simple holder

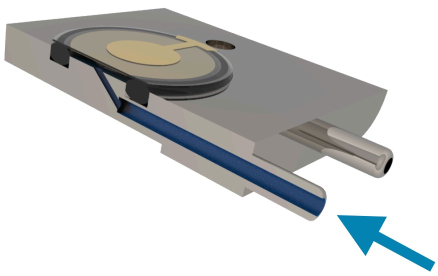


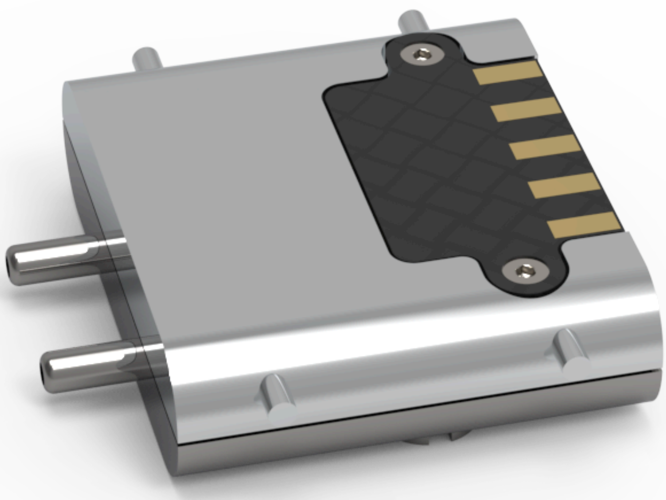
The fluidic module is the real core of openQCM NEXT. Composed of two metal parts: the lower part, made of electropolished aluminium will be in direct contact with the Peltier element, and the upper part, composed of Nickel electroplated stainless steel (or PTFE where the samples are particularly sensitive to interactions with metals).

All other materials are specifically selected in order to have the widest range of chemical compatibility with your samples.

The fluidic circuit is directly engraved inside the top cover of the module, in order to enhance thermalisation of the incoming fluid. Furthermore, we inserted a silica glass window for visual or spectroscopic inspection (optional). If you need for specific spectral bandwidth, silica window, can be easily removed, in order to be replaced with your own optical window. Furthermore the fluidic module is designed as a plug-ad-play accessory that can be easily unplugged for treatments “out of the device” (eg: ultrasonic bath, thermal baking etc.)

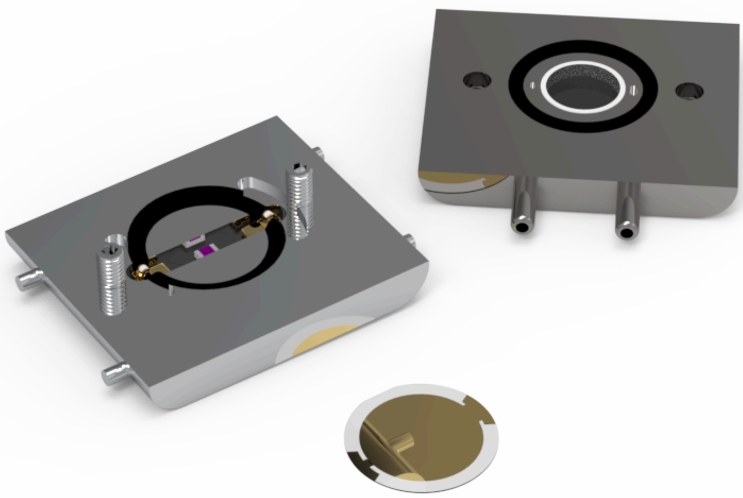
Inlet and outlet lines, enter in the measurement chamber with a specific tilting angle, in order to reduce flow perturbation effects on the baseline (eg.: peristaltic waves), mainly during the pumping phase.





Just below the bottom quartz surface, a 10K thermistor monitors the internal temperature of the fluidic module. Electrical contact pads on its micro-PCB are produced by immersion gold technique. This process, drastically reduce the oxidation effects and consequently a degradation of S/N with the time.

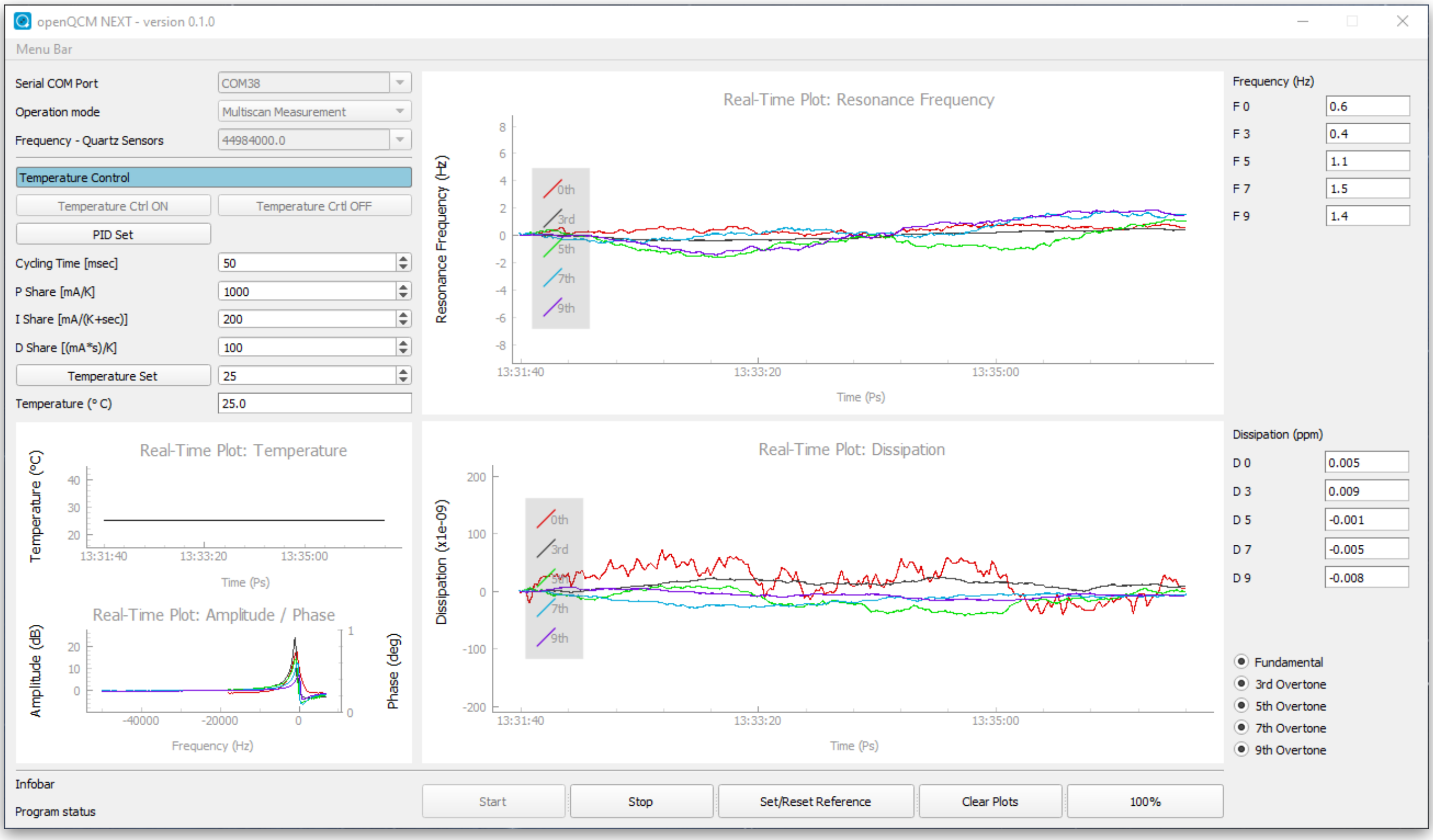
	Sample exposition	Material	Surface treatment
Bottom	No	Aluminium 6063	Flash chrome plating
Top	Yes	Stainless Steel	Ni electroplated
Window	Optional	SiO2	
Window frame	Yes	PTFE	
O-ring	Yes	Viton (FKM)	
Electronics	No	FR-4	



SOFTWARE

openQCM NEXT Python Application

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



The opeQCM NEXT software is developed in Python, which is an open source, object - oriented and suited for scientific application programming language. 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. Mainly it is possible to acquire almost simultaneously 5 sweep signals and elaborate the frequency and dissipation measurement in roughly 700 msec. In addition, the application allows to control and monitor the sensor module temperature in real time.

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
Working temperature	15 - 45 °C (nominal temperature Peltier range 5 °C - 45 °C)
Control direction	Heating and Cooling
TEC element	Peltier

Measurement Specification

Physical quantities	Frequency and Dissipation
Measurement mode	Simultaneous multi - overtones (up to 9th overtone for 5 MHz quartz sensors)
Minimum Sampling time	~ 125 ms for each harmonic

Hardware and Material Specification

Fluidic module material	Nichel electroplating Stainless steel (top cover exposed to the sample) , Flash chrome plating Aluminium (bottom)
Fluidic module window material (optional)	Quartz glass, Viton (FKM) oring and PTFE sealing frame
Heat sink material	Flash chrome plating Aluminium
Main case material	Aluminum 6061 and Nylon plastic PA2200
Main Dimension	(L x W x H): 20 x 8 x 4 cm
Core sensor dimension	(L x W x H): 2.5 x 2.5 x 0.5 cm
Weight	260 g

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)Stainless steel, aluminum	
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

Power

Main electronics	USB 5VDC powered (cable included)
Peltier module	5 VDC through 220 VAC adaptor (adaptor 220VAC - 5VDC USB included)

Note: All specifications are subject to change without notice.