Technology Note

Custom Sensors

Summary

Use of custom-coated QCMD sensors with AWSensors instruments is compatible. The AWS Suite has a Custom Sensor feature that allows the user to add them to their sensor list and to configure their electrical parameters so that the software can perform a proper resonance finding in the experiments.

Introduction

AWSensors instruments can characterize a wide range of sensors: classical low-frequency (5 MHz to 10 MHz) QCMD, high-frequency (HFF) QCMD, and Love- Surface Acoustic Wave (Love-SAW). Furthermore, an important aspect of the AWSensors QCMD technology is the flexibility the customer has in terms of surface coatings of the QCMD sensors. The AWS Suite software includes the default configurations for many "standard" sensors supplied by us. Moreover, it allows the user to work with custom sensors, where the coating has affected the resonance properties. Some third-party sensors, compatible with the AWSensors measurement cells, may also benefit from this feature.

Up to five custom sensors can be defined by the user by introducing measured resonance properties. This Technical Note provides a description of this feature and a step-by-step guide for its use.

Materials and Methods

General requirements

Instrumentation. This process is compatible with the X1 and X4 instruments. A measurement cell compatible with the sensor type to be used is required. Figure 1 shows the available measurement cell / sensor combinations.

Software. This feature is available in AWS Suite version 4.0.x or greater.

	AWSensors CELLS					
APPLICATION	IN-FLOW	IN-BATCH	EQCM	EQCM/FLOW	AIRTIGHT	PROBE
SENSOR						
QCM 14mm WRAPPED	✓	✓	✓	✓	✓	✓
QCM 1" WRAPPED	✗	✓	✓	✗	✗	✓
LOVE-SAW	✓	✓	✓	✗	✗	✗
HFF-QCM	✓	✓	✓	✓	✗	✗

Figure 1: Possible combinations of acoustic sensor and measurement cell type available for AWSensors instruments.

General procedure

In order to configure the new sensor in the software, the resonance properties of the sensor have to be characterized. To do this, use the Sweep Tool in the AWS Suite. By performing sweeps in the appropriate frequency ranges, one obtains the resonance frequency of the sensor (defined as the frequency at maximum conductance) at multiple harmonics. The procedure can also be used for sensors that function only on the fundamental.

To define the custom sensor in the software, please follow these steps:

1. Assemble the sensor in an appropriate cell and

mount it in your QCMD instrument. Do not fill the cell with liquid since the measurements will be performed in air.

2. Open the AWS Suite and connect to the QCMD device.
3. Open the Sweep Tool.
4. Pick the sensor configuration (Figure 2) that best matches your custom sensor in terms of nominal fundamental frequency and format (14 mm vs. 1 inch, for example).
5. Start a sweep with the default parameters for the selected sensor configuration. Figure 3 shows the sweep for a 14 mm, 5 MHz sensor. A very narrow conductance peak is observed, typical for the measurements in air.
6. Narrow down the frequency range around the

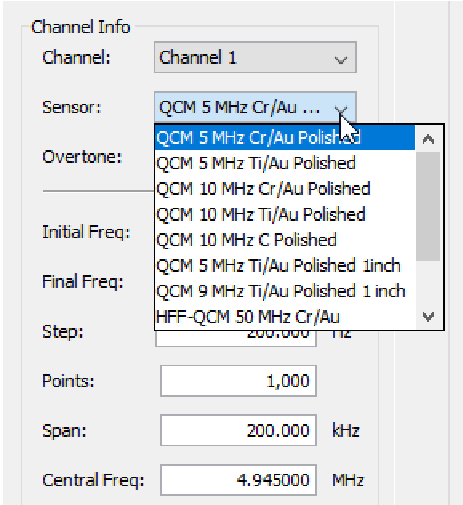

Figure 2: Example of sensor configuration options in drop-down menu in the Sweep Tool.

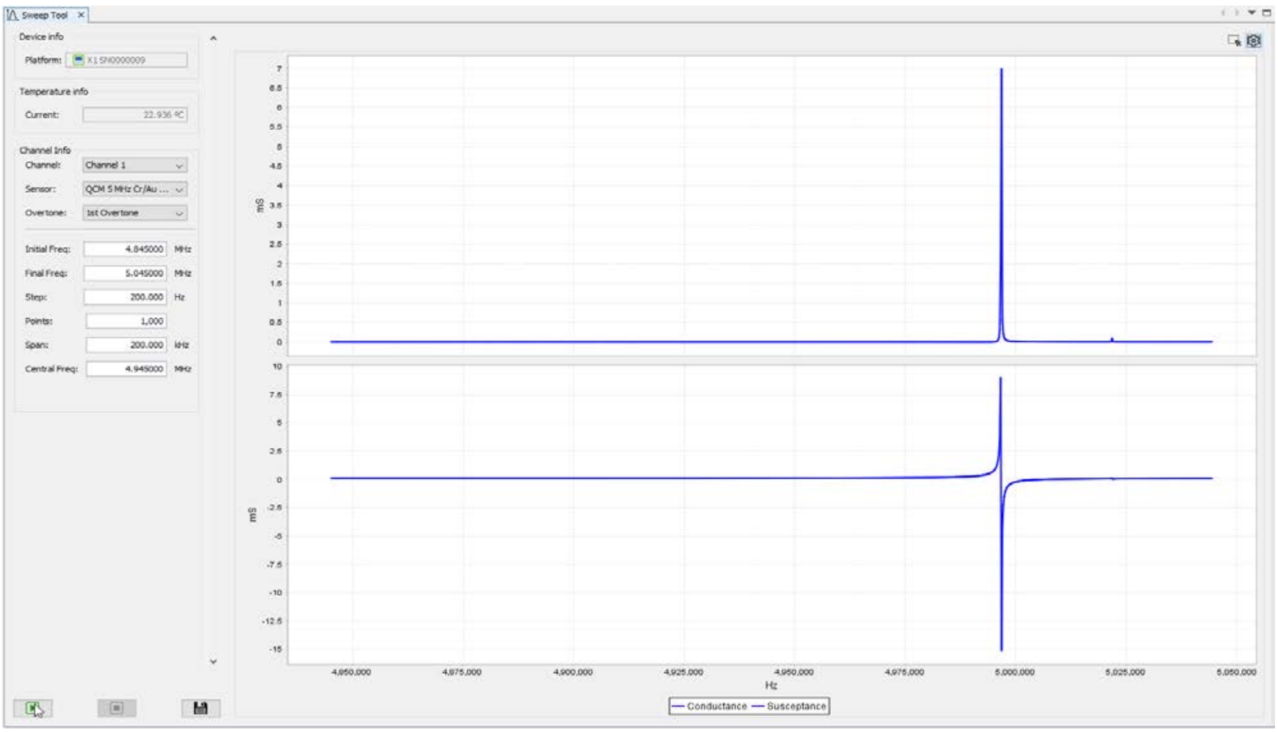

Figure 3: Image of Sweep Tool after a sweep with standard values (QCM 5Mhz Cr/Au sensor) has been performed on a particular 14 mm, 5 MHz custom sensor.

resonance by modifying **Initial Freq**/**Final Freq** or **Central Freq**./**Span** fields in Figure 3. Keep the # of **Points** at 1000. Figure 5 shows a sweep of the same sensor acquired with a **Span** of 1 kHz instead of the initial 200 kHz span (as shown in Figure 4).

7. Save the sweep for your records if you wish.
8. Determine the frequency at which the conductance is at the maximum. This can be done visually, by zooming in the sweep, ensuring the conductance peak is well defined (e.g. by using 1 kHz span, 1000 points, achieving 1 Hz resolution in the measurement).
9. Repeat these measurements for each overtone allowed to your sensor type. For instance, if you have a 5 MHz sensor, you can measure up to the 13th overtone; a 50 MHz sensor can measure up to the 3rd overtone; etc.

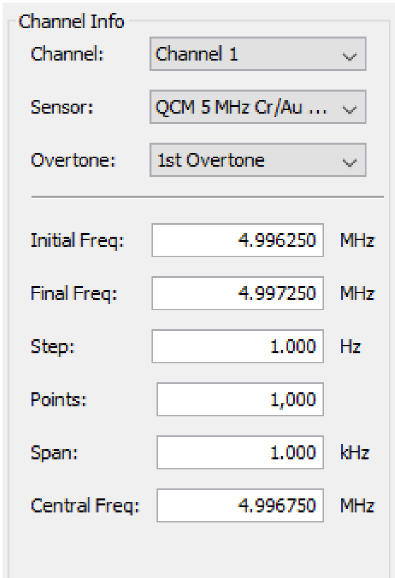

Figure 4: Sweep tool parameters have been modified to measure a narrower range in frequency. The sweep measurement is configured to take 1000 points in a step of 1 Hz, thus covering a span in frequency of 1kHz.

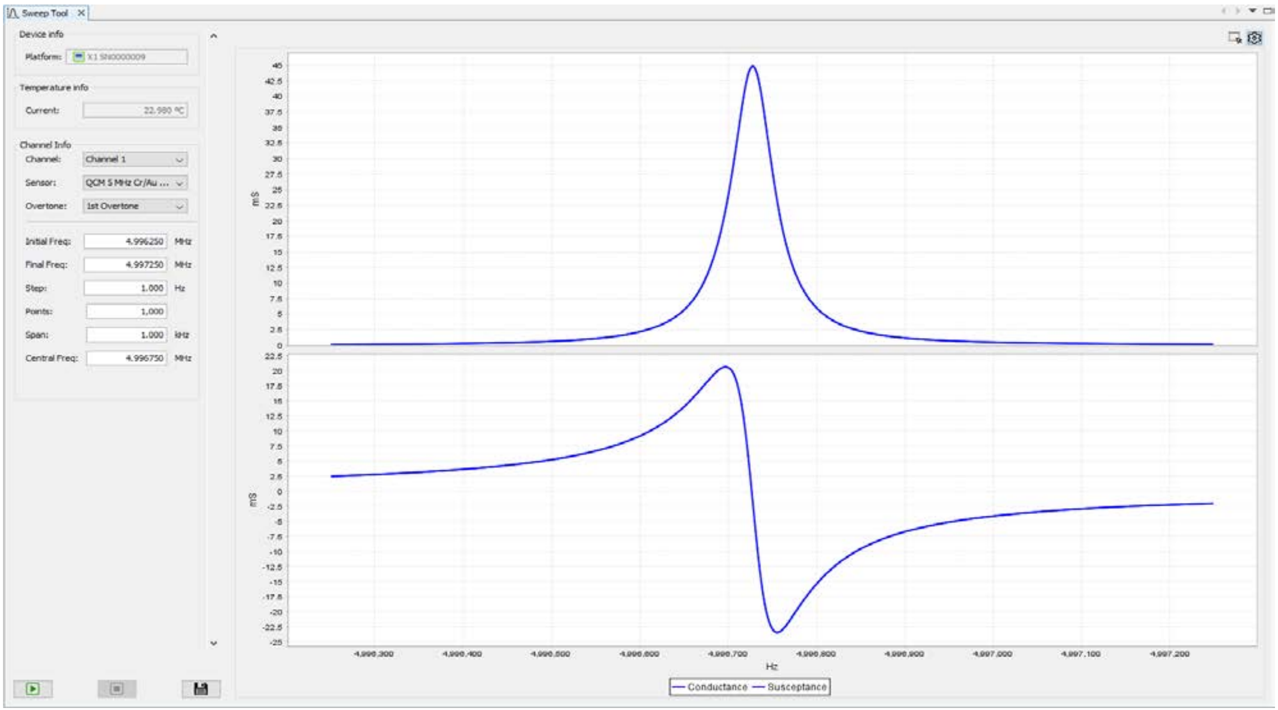

Figure 5: Image of Sweep Tool after a sweep with narrowed frequency range and same number of points has been performed.

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10. In a third-party analysis software, such as MS Excel, organize the frequency data calculated by overtone tested as shown in in Table 1, where "Freq (Hz) – measured", is the resonance frequency obtained from the sweeps and the "Freq (Hz) – theory" is the expected frequency at the given overtone *n*.
11. Calculate **F/n** and plot it against ***n*** to visualize the dependence of the resonance frequency on the overtone order (Figure 6).
12. Calculate the difference between the expected frequency and the measured one for each overtone.
13. Plot the difference calculated in the previous step vs *n* and perform a linear fit (Figure 7). Do not set the intercept to zero, and display Equation and R^2 on chart.

Go back to the AWS Suite and add our custom sensor to the sensor library of the software:

14. Open the "Sensor Visualization Tool" by clicking on "Configure Sensor list" within the **Device** menu in the AWS Suite.
15. A pop-up window will open (Figure 8). Click on the "Custom Sensors" tab.
16. Enable a Custom Sensor, by ticking the box of a Custom Sensor line. It will enable the configuration fields.
17. Introduce a description for the sensor. This **Description** will be used to identify the sensor in the drop-down menus for sensor configuration, such as the one shown in Figure 2.
18. Input the nominal frequency of the sensor in the **Frequency (MHz)** field.
19. Introduce the **Slope** and **Offset** values obtained from the linear fit calculated in Step 13.
20. Press OK to save and apply the configuration of the new custom sensor. From now, it should be visible in the Sensor configuration menus in the AWS Suite, unless otherwise disabled by unticking the specific

Table 1: Example of the data calculated for a 5 MHz sensor. The resonance frequency extracted from the sweeps (Freq (Hz) - real) is organized by number of overtone (n). Additional parameters calculated are real frequency normalized by overtone number, the theory frequency for each overtone, and the difference between the theory frequency and the real one measured.

#	Freq (Hz) - measured	n	F/n (Hz, measured)	Freq (Hz) - theory	diff(theory-measured)
1	**4971620**	1	4971620	5000000	28380
2	**14898335**	3	4966112	15000000	101665
3	**24827590**	5	4965518	25000000	172410
4	**34755475**	7	4965068	35000000	244525
5	**44684000**	9	4964889	45000000	316000
6	**54612300**	11	4964755	55000000	387700
7	**64541200**	13	4964708	65000000	458800

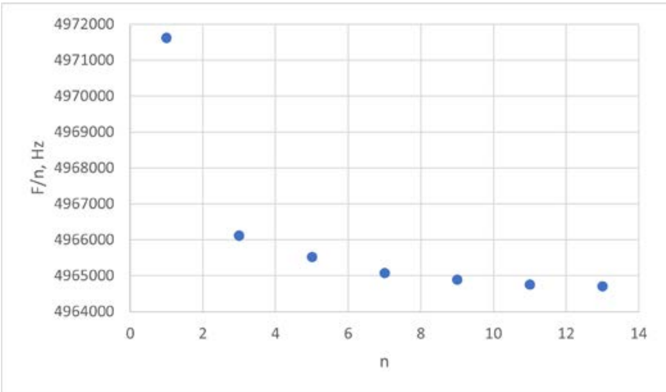

Figure 6: Plot showing the frequency dependence over overtone number for the example 5 MHz sensor.

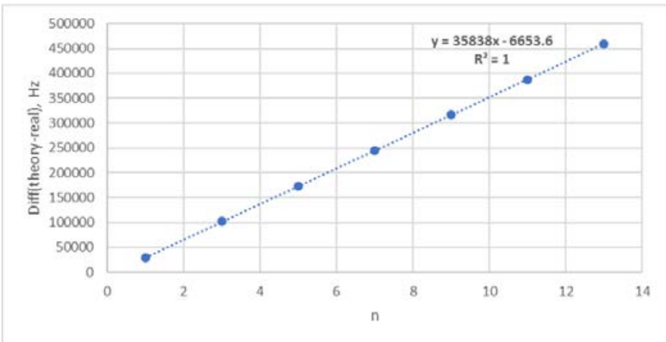

Figure 7: Plot of the difference between the theory frequency and the real frequency vs the overtone. It shows the linear fit trendline, including equation, where the slope and offset are defined, and R^2.

custom sensor tick box.

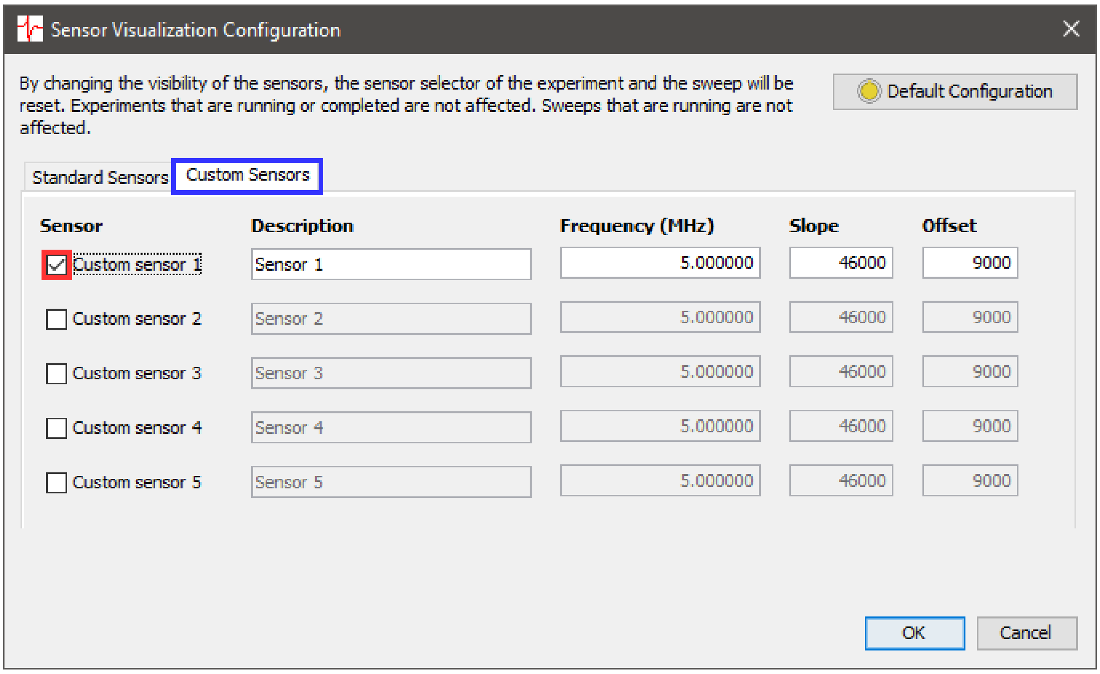

Figure 8: Sensor Visualization Configuration window. The "Custom Sensors" tab (blue) is displayed. "Custom sensor 1" has been enabled by ticking the respective tickbox (red).

Additional Notes

An MS Excel template file is available upon request.

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