DUAL QUARTZ CRYSTAL MICROBALANCE

1. General considerations.

This software program allows mass and film thickness measurements with two different quartz crystals. It works as two different microbalances A and B. It is thus possible to perform synchronous measurements with two different quartz crystals (AT, BT, SC etc) or with similar quarts crystals in two different conditions.

For each quartz crystal the program measures and displays series resonant frequency and series resistance. In addition it measures a temperature using a PT-1000 temperature sensor and a crystal current using a RF transformer.

By choosing the overtone number **n**, frequency constant **N**, film density **D** and deposition area **Su** the program calculates the film thickness $\mathbf{L_f}$ and film mass $\mathbf{M_f}$, using the equations based on the Energy Transfer Model [1]. These equations were experimentally proved up to a mass load of 37%, while the Saurbrey's equation can only be used up to a mass load of 2%.

$$L_f = \frac{1.324N}{nDF_0}\left(\frac{F_0^{\,2}}{F^2}-1\right)$$

$$M_f = \frac{1.324NSu}{nF_0}\left(\frac{F_0^{\,2}}{F^2}-1\right)$$

Where F_0 is the frequency at the starting of the measurements (record) and F is the current frequency. The constant 1.324 is just half the quartz density in (g/cm^3)

Measurements with AT-cut quartz crystals (N=1.67 MHz . mm) vibrating on their fundamental mode (n=1) are set as default.

2. Gate time.

By choosing 1s the frequency measurement resolution is 1Hz; choosing 10s the resolution is 0.1Hz and choosing 100s the resolution is 0.01Hz.

3. Interpolation.

The program allows interpolation between two measured values. When a gate time of 10s is used, it is possible to have a resolution of 0.01Hz. In this case the measured values are delayed 10s, but they are synchronized so that they look like real time measurements. When interpolation is chosen before starting a record, it is necessary to wait for about 30s before starting the record.

4. AutoCal

This function performs an automatic calibration. It must be used, for instance, when the temperature sensor was connected to the instrument after the program was launched.

5. Offset resistance R_0

When a small difference is noticed between the series resistance value measured with QCM -3 instrument and the value of this resistance measured with a calibrated network analyzer for a crystal current of 0.7 mA, it is possible to make a correction, by introducing the appropriate value of the offset resistance which will be subtracted from the value shown by QCM -3, so that the two instruments should display the same value for the series resistance of the sensor crystal.

6. Offset current

When a small crystal current is displayed while the crystal is not vibrating it is possible to cancel this offset by pressing Iq 0.0.

7. Graphic record

Y-axis: On each channel, frequency, resistance, film thickness and mass can be displayed.
Sensitivity (u/div) can be chosen to fit the graph into the graph area.
Automatic offset (ao) moves the graph into the graph area, close to the X-axis.
Displayed graph (on). Graphs are displayed inside the graph area with different colors. It is possible to choose only the desired graphs. However, measurements and calculations are performed even when a graph is not displayed. With these data a graph can be reconstructed whenever during or after the record. One or several graphs can be removed during the record, but the corresponding data are acquired continuously.
X-axis: Normally time recorded graphs are displayed. When both temperature and crystal current are also time recorded, the Y-time graphs can be converted into Y-temperature or Y-current graphs by using the switch for X-axis.

8. Starting measurements

Before starting measurements it is necessary to choose **n**, **N**, **D**, **Su** and **R_0,** gate time and interpolation. For AT-cut crystals, vibrating on their fundamental mode, **n** and **N** are set by default. After pressing START, one should choose which parameter to be displayed (on), sensitivity (u/div) and then automatic offset (ao). By decreasing the offset value the graph will move slowly upwards to the appropriate position.

On X-axis one can choose the time scale and offset. If temperature T_p and crystal current I_q are also recorded, the Y-time graphs can be converted into Y-temperature or Y-current graphs.
To stop the measurements just press STOP. The measured and calculated data can be saved or not. If saved, these data can be loaded later by marking the file name and pressing LOAD.
It is possible to read the numerical values on each point of a certain graph by placing the crossing lines in that point. The Y and X numerical values will be displayed in two windows situated under the graphs area.
During the measurements a text can be added to specify the experimental conditions. To do this just press TEXT.

9. Print preview

During the measurements or after saving the data it is possible to see a print preview by pressing PRINT. It is possible to add a "Caption" to explain the measurements and a "TITLE". This print preview can be printed directly by pressing PRINT, or it is possible to return to the main graphs by pressing RETURN.

10. Data export

It is possible to export only the data included in the displayed graphs by pressing EXP.G. A text file is created which can be exported to another program, where the data can be further processed or graphically displayed.
It is also possible to export all the measured and calculated data, not only those shown in the graph, by pressing EXP.A.

11. Exit from the program

To exit the program press QUIT.

References

[1]. V.M. Mecea. Loaded vibrating quartz sensors, *Sensors and Actuators A*, 40 (1994) 1-27.