Authors comment on: "Electrical Analogy to an Atomic Force Microscope"

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In [1] I used assumptions which proved to be wrong in further research.

First of all, the analogy used is called "force–current", not "force–voltage" as erroneously written in Sec. 3 [1]. The second inaccuracy concerns the mechanical model proposed in Sec. 2. This configuration of the model is appropriate for analysis of dynamic response of the unloaded cantilever, as was proved in Sec. 4. However, when this model was used to analyze the measurement of biological samples, it has given results contrary to the experiments. Bio–samples have typically lower stiffness than technical specimens. It means, that their spring constant, κ, is comparable to the spring constant of the cantilever, k. The springs are not matched and the measured topography is "attenuated" due to the indentation of the probe into the sample. The presented model has not shown such behavior.

The correct model of the system is described by equation of the motion

$$m\frac{\mathrm{d}^2 z_1}{\mathrm{d}t^2} + \beta\frac{\mathrm{d}z_1}{\mathrm{d}t} + (k+\kappa)z_1 = \kappa z_3, \tag{1}$$

and depicted in Fig. 1.

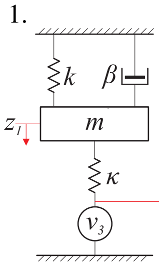

Fig. 1. Corrected mechanical model of the sample-–tip-–cantilever system.

Electrical analogy to this model is shown in Fig. 2. Transfer function of such circuit can be written as follows

$$H_p(p) = \frac{\mathcal{L}[u_c(t)]}{\mathcal{L}[u(t)]} = \frac{L_1 R}{p^2 L_1 L_2 RC + pL_1L_2 + L_1R + L_2R}. \tag{2}$$

This model is consistent with experimental experience of indentation of the probing tip into the sample (for details see Fig. 3). The model can be expanded along the same lines as presented in [1].

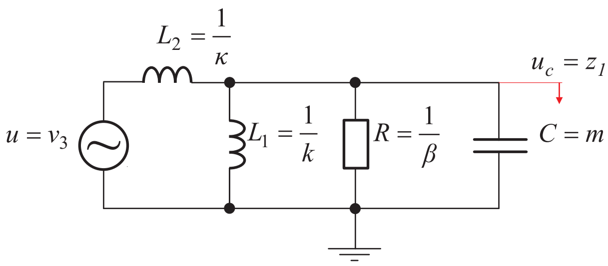

Fig. 2. Corrected electrical analogy to the sample-–tip-–cantilever system.

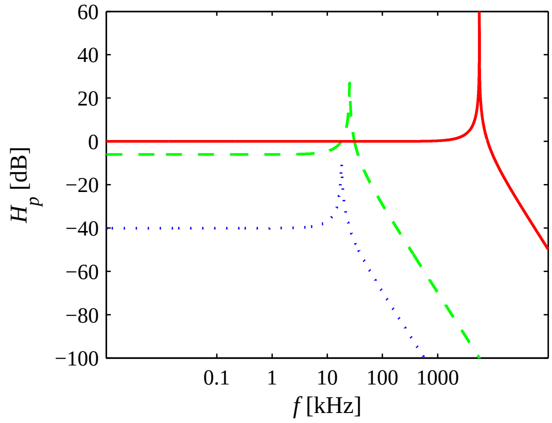

Fig. 3. Frequency response (magnitude) of the corrected model for three different values of sample stiffness. $k=\kappa=0.05$ N/m dashed line, $k>\kappa=0.005$ N/m dotted line, $k<\kappa=5000$ N/m solid line. Parameters of the cantilever are $m=3.909^{-12}$ kg, $k=0.05$ N/m, and $\beta=1.418^{-8}$ Ns/m.

The mistaken model was inspired by the fact, that in (14) – the frequency response of a loaded cantilever – in [2] is wrong, missing one square in the denominator.

References

[1] KUČERA, O. Electrical analogy to an atomic force microscope. *Radioengineering*, 2010, vol. 19, no. 1, p. 168 - 171.

[2] GITTES, F., SCHMIDT, C.F. Thermal noise limitations on micromechanical experiments. *European Biophysics Journal*, 1998, vol. 27, n. 1, p. 75 - 81.