Multi-PLL detection system for high resolution scanning probe microscopy

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In various advanced scanning probe microscopy measurements, multiple signals have been generated to excite the cantilever. The responses can measure various physical properties of materials. For example:

(i) in Kelvin probe force microscopy, variations of the local work function on surfaces are measured by applying an additional AC electric field between tip and sample [1].

(ii) in bimodal atomic force microscopy, two or more mechanical oscillations are used to gain a higher sensitivity to short-range interactions. Consequently, improved resolution on the atomic scale [2] as well as additional material contrasts can be achieved [3].

(iii) Generation and analysis of higher harmonics of the cantilever oscillation can be used in the characterization of materials [4], the reconstruction of tip-surface interactions [5] or the acceleration of measuring 3D force fields.

(iv) Generation of patterned pulses synchronized to the cantilever oscillation in a pendulum setup to orient atom spins.

All these methods require a well-suited and highly sensitive electronics to generate, receive, and process the signals of the cantilever.

We developed a novel digital controller, called Saphyr. It combines up to four PLL modules, one of them can be replaced by a special Kelvin controller module, two free definable PI controllers, and a pulse generator, with high performance, precision and modularity. Furthermore several advanced functions such as a variable higher harmonics generation and detection are implemented. All these modules and functionalities can be controlled with our developed software.
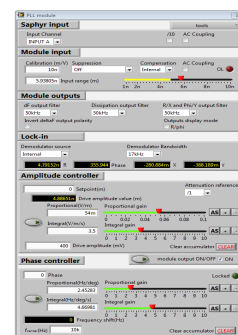
Figures: (a) Saphyr controller   (b) a screen shot from the software.

References

[1] S. Sadewasser and Th. Glatzel, Kelvin Probe Force Microscopy, Springer (2011).
[2] S. Kawai, et al., Phys. Rev. Lett. **103**, 220801 (2009).
[3] R. Garcia et al., *Nat. Mater.* **6**, 405, (2007).
[4] A. Raman et al., *Nat. Nano.* **6**, 809, (2011).
[5] C. Hutter et al., Phys. Rev. Lett. **104**, 050801 (2010).