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Realisation of a phase-locked loop for a dynamic mode scanning force microscope with a tuning fork sensor

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The instrument set up consists of a vacuum AFM system which uses a quartz tuning fork with a resonance frequency of typically 32 kHz as a force sensor. An etched tungsten tip is glued to the vibrating end of the quartz. The frequency of the quartz is measured with a high resolution (5mHz) and high stability (3mHz/°C) phase-locked loop (PLL) manufactured by Nanosurf. The electronics has been modified so that it is not only capable to measure the resonance frequency of the quartz with high precision but also excites the quartz tuning fork. Consequently, the frequency of the excitation voltage which drives the tuning fork can be controlled so that the tuning fork oscillates at a fixed phase shift. To achieve that optimum phase condition, a phase shifter is added and the internal proportional controller of the PLL circuit is enhanced by an integrator circuit.

Frequency shift vs. distance curves at different tip-sample voltages

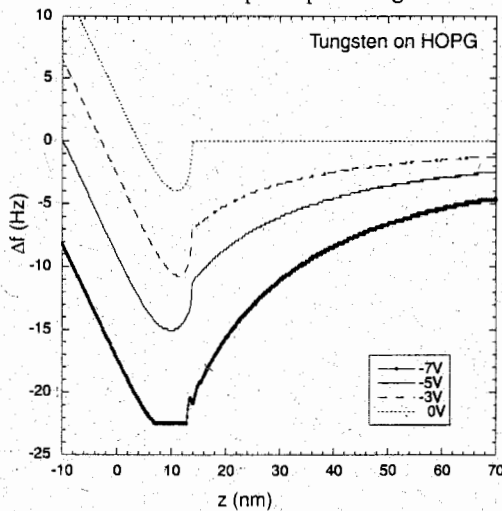
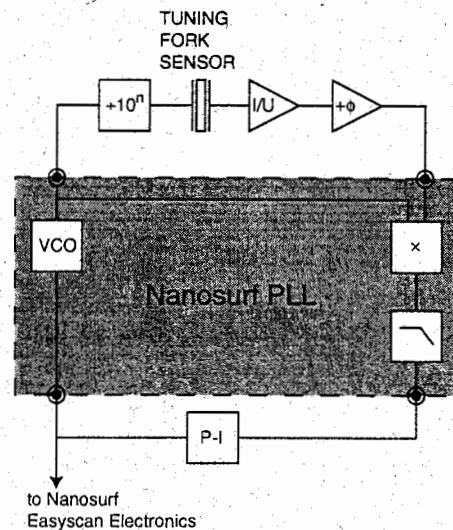


Diagram of the modified Nanosurf PLL



AFM measurements have been successfully carried out using the system described above. Due to the high stability of the PLL it was possible to measure each frequency/distance curve over a relatively long time periode of up to several minutes.