Mathematical Lock-In Detector Module

NANONIS SPMCS-LD-2

The SPMCS-LD-2 module adds a lock-in detector to the Nanonis SPM Control System. The lock-in allows the user to perform all kinds of differential measurements like dI/dV, CITS, inelastic electron tunnelling spectroscopy (IETS), measurements of open and closed loop transfer functions and all other kinds of phase sensitive measurements.

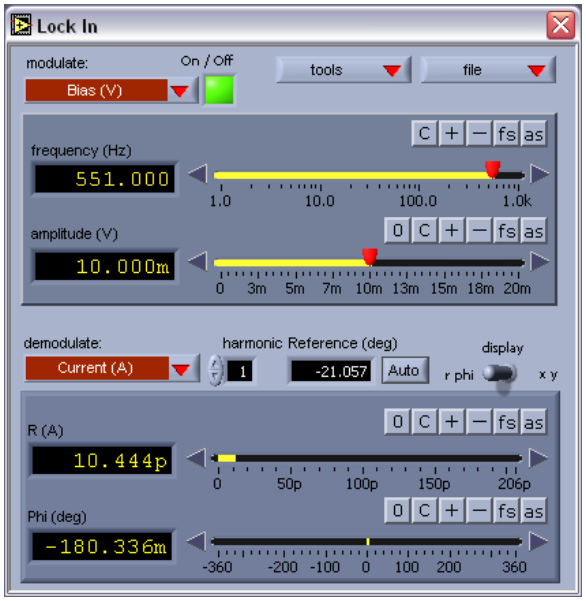

Fig.1: Screen shot of the lock-In module. The modulated and demodulated signal can be chosen from the 24 signals available in the Nanonis SPM Control System. All signals and parameters are in real world physical units.

With this software lock-in you can modulate any signal in a frequency range of 0-2kHz and detect the response on another signal. Due to its implementation with floating point numbers the lock-in has an extremely high dynamic range: there is no need to adjust an input sensitivity or calibrate output voltages. All signals and parameters are in real world physical units and transparently available throughout the system. The output channels can be recorded in all experiments of the Nanonis software. In particular, these outputs are available for point or grid spectroscopy as well as while scanning.

A further advantage of the software lock-in compared to an external realisation are the perfectly synchronous filters. The output channels (Lock-In X and Y) are calculated by averaging exactly one period of the reference frequency without the necessity to choose a time constant. The result is higher accuracy and lower noise.
The module saves the cost for an additional external lock-in amplifier and is ready-to-use in just a few clicks. No need to do tedious BNC cabling which can introduce unwanted disturbances, ground loops and noise sources.
A special frequency sweep routine allows for the recording of loop transfer functions. The frequency response of the feedback controllers for tip-sample distance, phase (PLL), amplitude or Kelvin Probe can be identified and displayed in logarithmic Bode plots as shown in Fig.2.

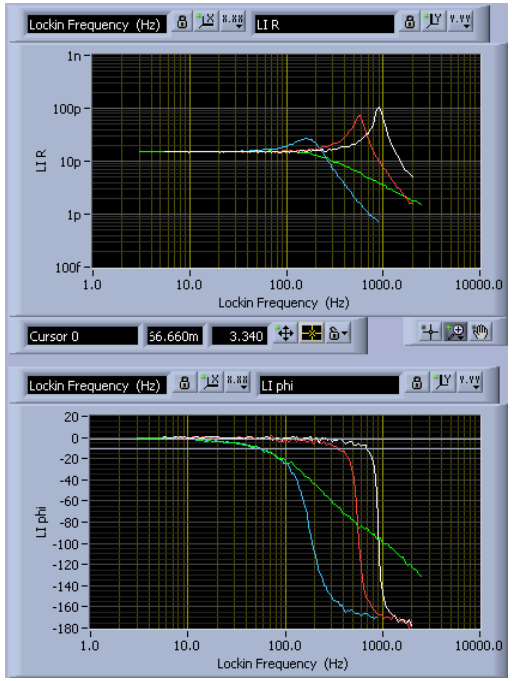

Fig.2: Example: closed loop transfer function of the z-controller in tunneling feedback. The bias voltage was modulated with 100mV and the z signal demodulated with the lock-in. Magnitude and phase is displayed as a function of the frequency (Bode Plot). Depending on the proportional and integral gain of the z-feedback an overshooting can be observed.

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