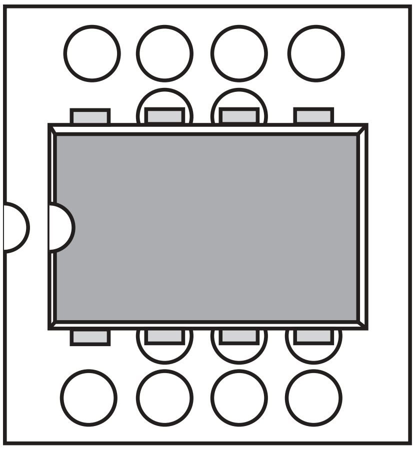
easyPLL

UHV Preamplifier

Reference Manual



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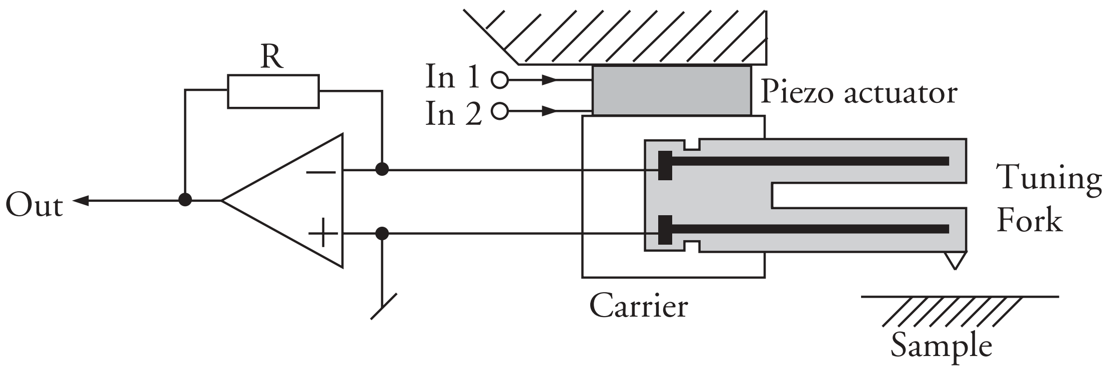
easyPLL UHV-Pre-Amplifier for Tuning Fork

Theory

For high resolution AFM measurements a sensor with high mechanical stiffness (high spring constant) is of geat interest. A quartz tuning fork with integrated tip not only offers this feature but simplifies things as simple electronics can then be used to detect the oscillation. The quarz tuning fork is built into an oscillation circuit as the resonance determining element and is operated at its resonance frequency. When scanning across the sample the variations in the resonance frequency are used to control the distance between tip and sample.

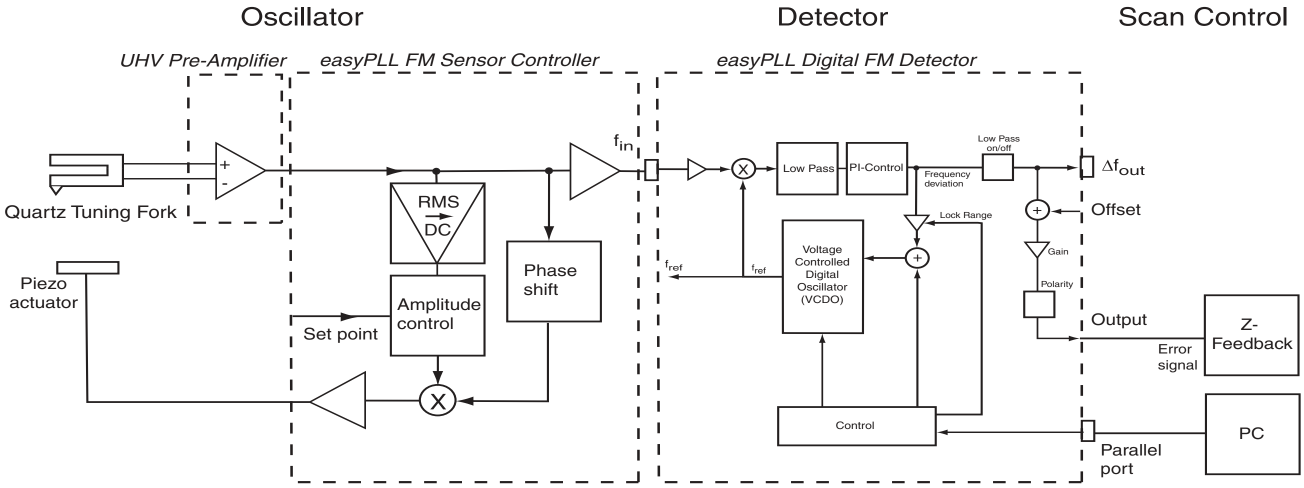
To integrate the quartz tuning fork into the electrical oscillator, two interfacing elements are needed: a transducer, used to convert the electrical excitation signal into mechanical oscillations and a converter, used to convert the forks response into a electrical signal.

A piezo electrical actuator is used as a transducer for the excitation signal. It is must be attached as close as possible to the basis of the fork and mechanically oscillates the quartz tuning fork at the excitation frequency. The movement of the fork's prongs is measured by electrodes situated on the prongs and converted into an electrical signal using a highly sensitive pre-amplifier.

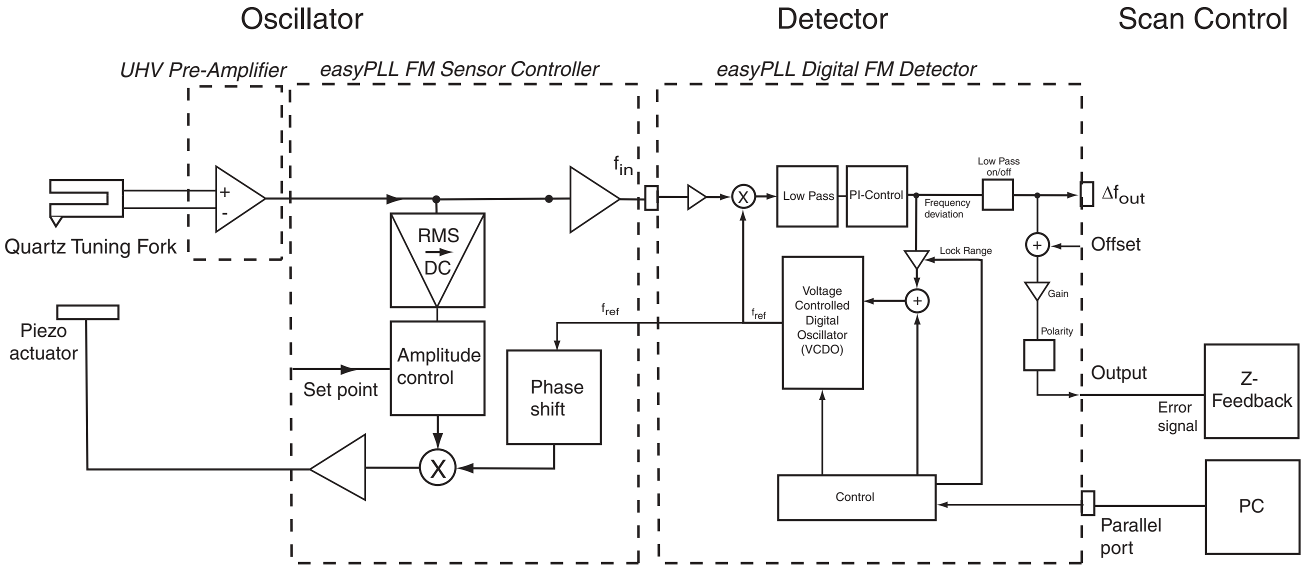


To minimize noise these two transducer elements have to be attached as close as possible to the tuning fork. This means the pre-amplifier must be constructed so that it is Ultra High Vacuum (UHV) compatible.

The rest of the excitation circuit can be set up outside the UHV and can be set up in two different ways. On one hand as a self-oscillator with subsequent frequency measurements and on the other hand as a PLL tracking oscillator. Both methods can be ideally implemented using the easyPLL FM Sensor Controller and the easyPLL Digital FM Detector.



self oscillator



PLL tracking oscillator

Wiring of the pre-amplifier

This section describes version 3.01 of the UHV preamplifier.

The pre-amplifier should be mounted in the UHV chamber as close to the quartz tuning fork as possible.

Use of 2 × 100 Ω resistors for Vs buffering and 10 kΩ resistor for tip bias buffering recommended (should be placed outside the vacuum chamber).

When mounting ensure that only UHV compatible materials are used!

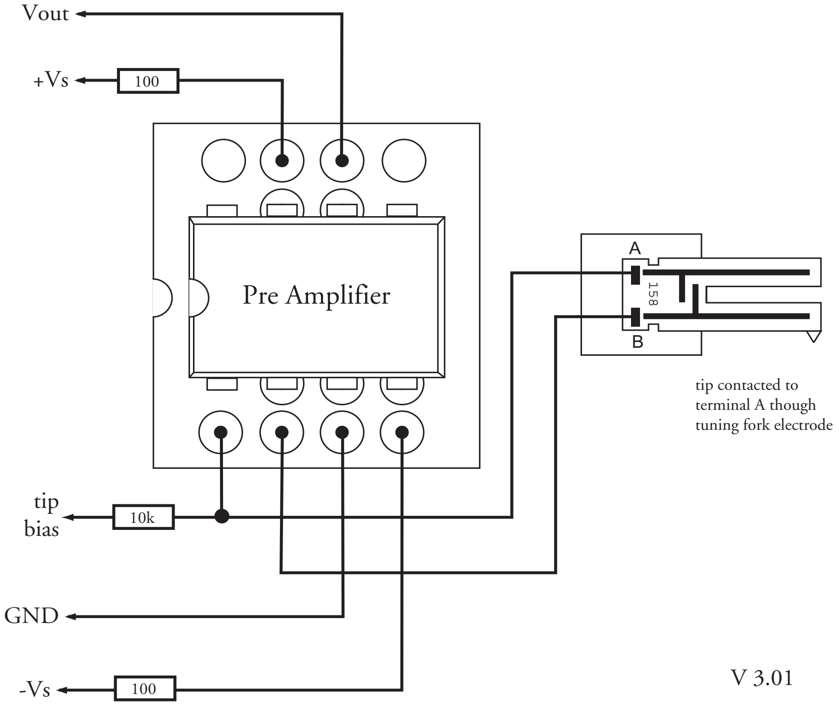
CAUTION: ESD sensitive device! Ensure that you are well grounded when mounting the per-amplifier so as to avoid electrostatic discharge which could destroy the pre-amplifier!

7 signals have to be fed into the UHV chamber:

- +15V power supply
- -15V power supply
- reference ground of the amplifier
- signal out of the amplifier
- tip bias
- piezo electrode 1
- piezo electrode 2

2 signals are connected to the electrodes of the quartz tuning fork:

- current input A of the amplifier
- current input B of the amplifier



Technical specifications

Power supply:	
Voltage:	± 15V ±10%
Quiescent current:	< ± 3mA
Sensitivity:	~1mV/Å
Noise:	150 fm/Hz½
	(when used with E158 qPlus sensor)
Max. tip bias:	±10 V
Storage temperature:	- 65°C to +150°C
Operation temperature:	- 40°C to +85°C
Feedback Resistor:	30 MOhm

Parameter	Min	Typ	Max	Units
INPUT OFFSET VOLTAGE[1]				
Initial Offset		0.3	**2**/**1**/**1**	mV
T_{MIN} to T_{MAX}			3/2/**2**	mV
vs. Temp		7	20/20/**20**	µV/°C
vs. Supply	**76**	95		dB
T_{MIN} to T_{MAX}	76/76/**76**			dB
Long-Term Stability		15		µV/Month
INPUT BIAS CURRENT[2]				
V_{CM} = 0 V		15	**50**	pA
V_{CM} = 0 V @ T_{MAX}			1.1/3.2/51	nA
V_{CM} = ±10 V		20	**100**	pA
INPUT OFFSET CURRENT				
V_{CM} = 0 V		10	**25**	pA
V_{CM} = 0 V @ T_{MAX}			0.6/1.6/26	nA
FREQUENCY RESPONSE				
Small Signal Bandwidth	3.0	4.0		MHz
Full Power Response		200		kHz
Slew Rate	**16**	20		V/µs
Settling Time to 0.01%		1.0	1.2	µs
Total Harmonic Distortion		0.0003		%
INPUT IMPEDANCE				
Differential		$3 \times 10^{12} \parallel 5.5$		Ω‖pF
Common Mode		$3 \times 10^{12} \parallel 5.5$		Ω‖pF
INPUT VOLTAGE RANGE				
Differential[3]		±20		V
Common-Mode Voltage[4]		+14.5, -11.5		
T_{MIN} to T_{MAX}	**$-V_S + 4$**		**$+V_S - 2$**	V
Common-Mode Rejection Ratio				
V_{CM} = ±10 V	**76**	88		dB
T_{MIN} to T_{MAX}	76/76/**76**	84		dB
V_{CM} = ±11 V	**70**	84		dB
T_{MIN} to T_{MAX}	70/70/**70**	80		dB
INPUT VOLTAGE NOISE		2		µV p-p
		45		nV/√Hz
		22		nV/√Hz
		18		nV/√Hz
		16		nV/√Hz
INPUT CURRENT NOISE		0.01		pA/√Hz
OPEN-LOOP GAIN	**150**	400		V/mV
	100/100/**100**			V/mV
OUTPUT CHARACTERISTICS				
Voltage	**+13, -12.5**	+13.9, -13.3		V
	±12/±12/**±12**	+13.8, -13.1		V
Current		25		mA
POWER SUPPLY				
Rated Performance		±15		V
Operating Range	**± 4.5**		**± 18**	V
Quiescent Current		2.5	**3.4**	mA

NOTES

[1]Input Offset Voltage specifications are guaranteed after 5 minutes of operation at T_A = +25°C.

[2]Bias Current specifications are guaranteed maximum at either input after 5 minutes of operation at T_A = +25°C. For higher temperatures, the current doubles every 10°C.

[3]Defined as voltage between inputs, such that neither exceeds ±10 V from ground.

[4]Typically exceeding -14.1 V negative common-mode voltage on either input results in an output phase reversal.

Specifications subject to change without notice.

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