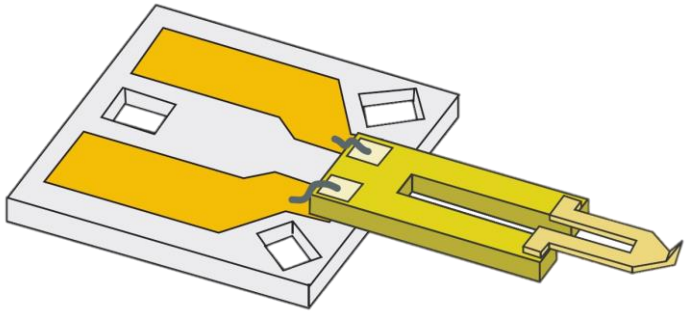
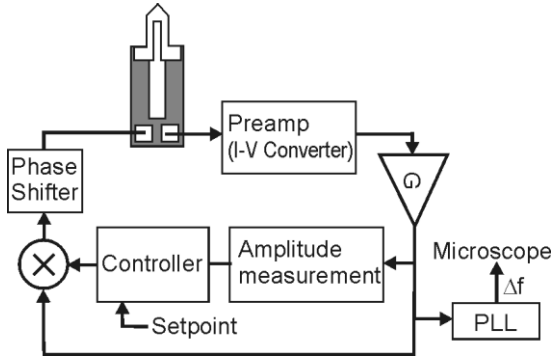
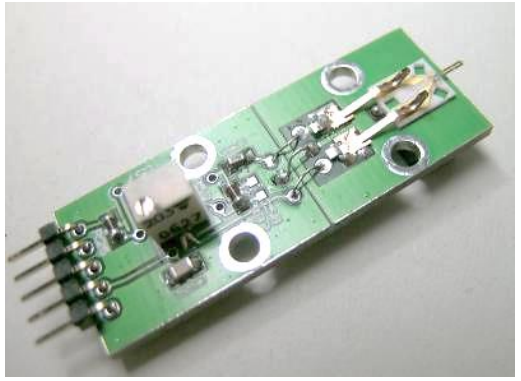
Akiyama-Probe (A-Probe)
simple DIY controller

This technical guide presents:

simple and low-budget DIY controller



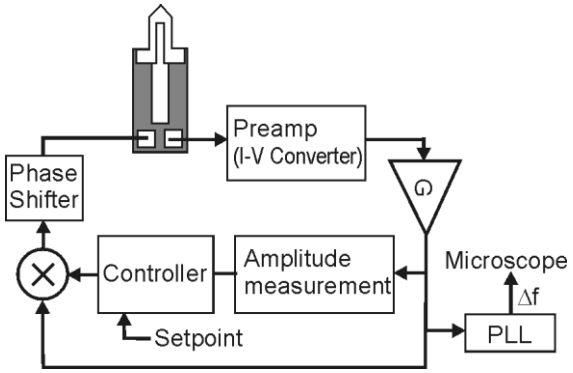


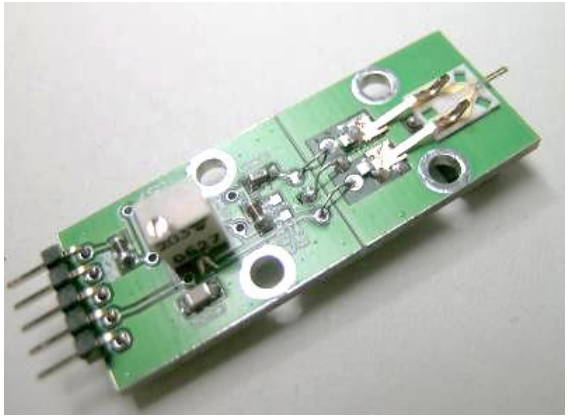


Version: 2.0

- NANOSENSORS has developed a simple and low-budget controller for operation of Akiyama-Probe. In this document, detailed information of the controller is disclosed for those who would like to make an own setup by themselves.
- *This is an additional customer service and only the technical information is provided. NANOSENSORS does not provide any of the products mentioned in this guide. Some contents in this guide may not apply to your specific setup. Please use this guide as a general reference only.*

Akiyama-Probe
Since 2006





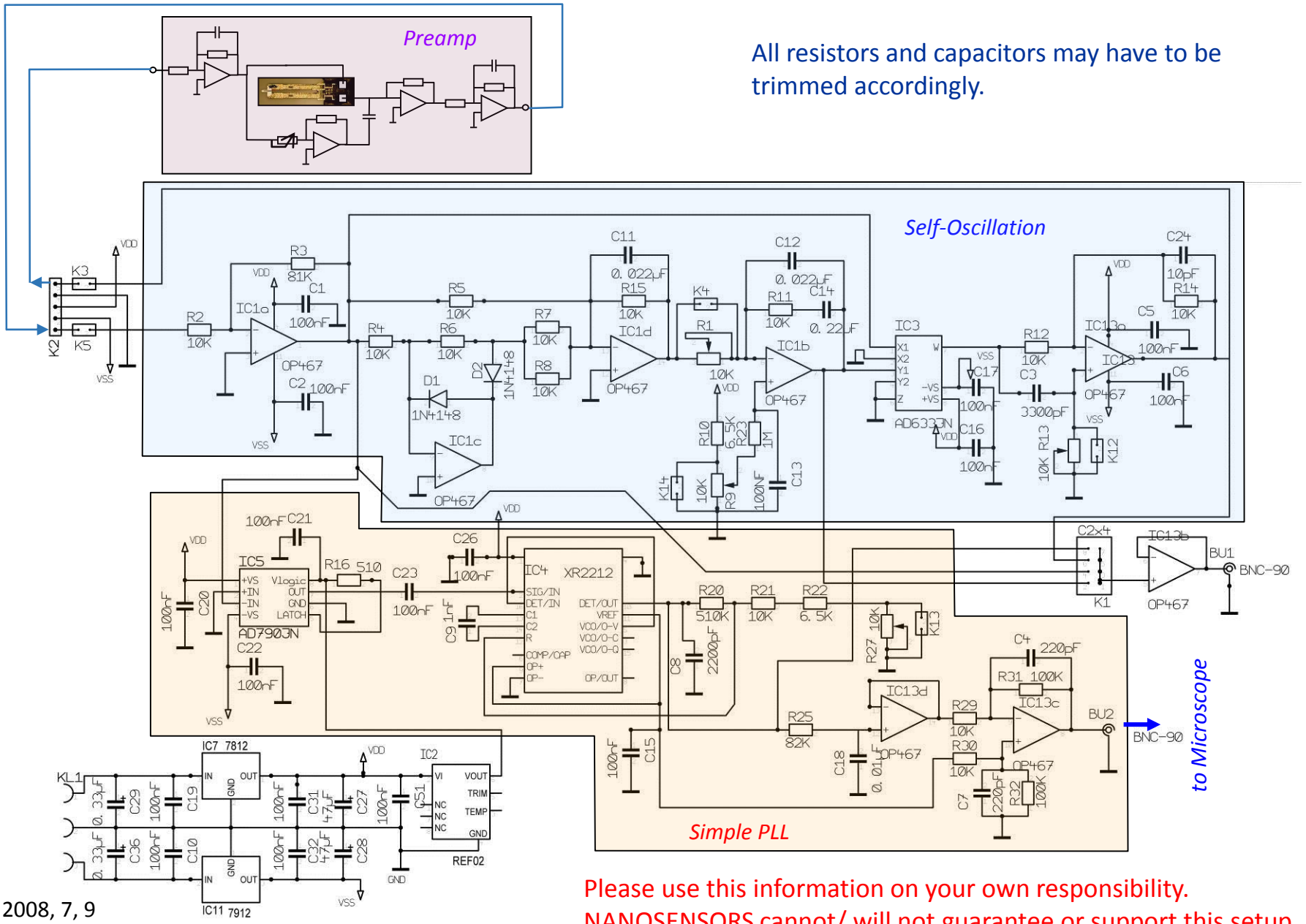
Preamp + Probe holder

Self-oscillation + PLL board

Akiyama-Probe is a patented technology.

Self-oscillation and simple PLL circuit

NANOSENSORS™
The World Leader in Scanning Probes

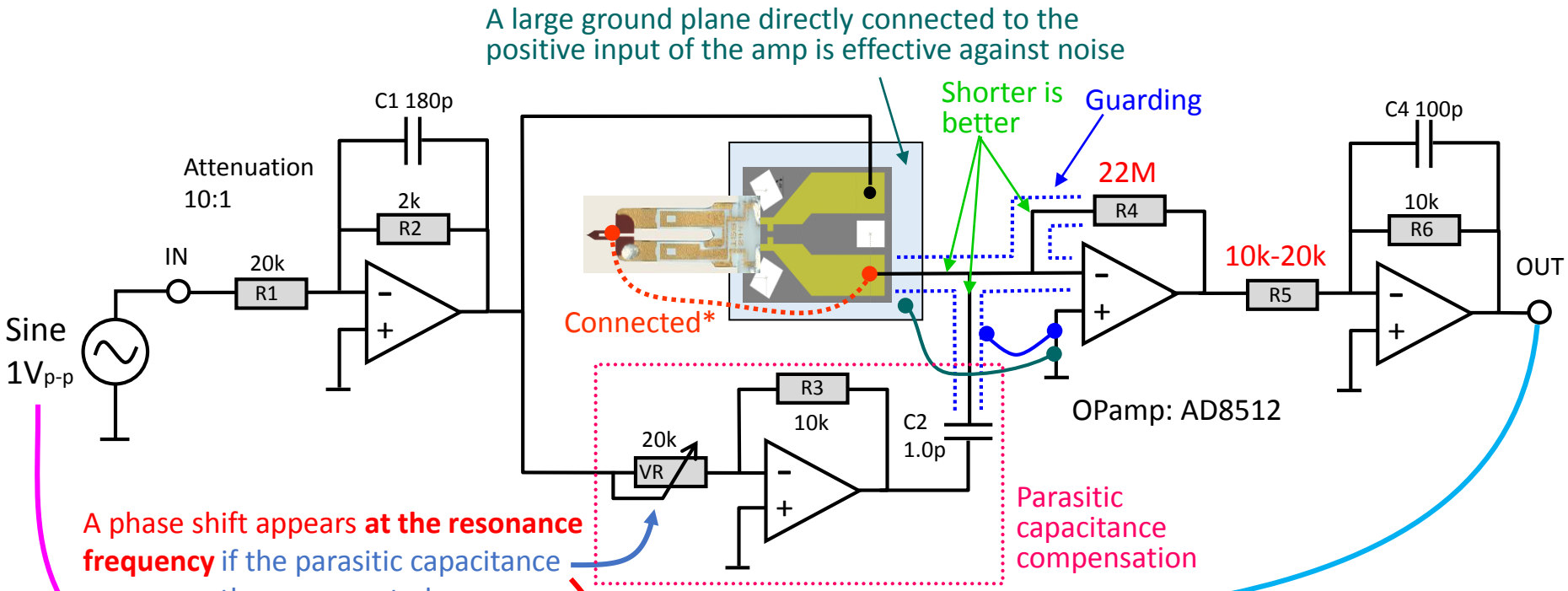


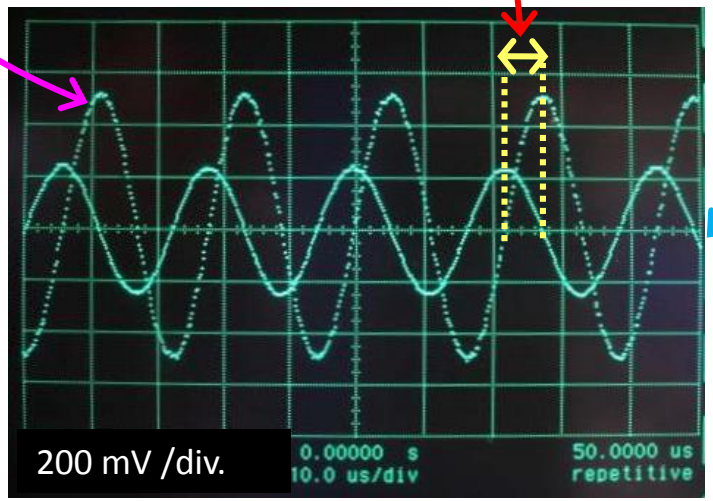
All resistors and capacitors may have to be trimmed accordingly.

2008, 7, 9

Please use this information on your own responsibility.
NANOSENSORS cannot/ will not guarantee or support this setup.

Configuration of preamp



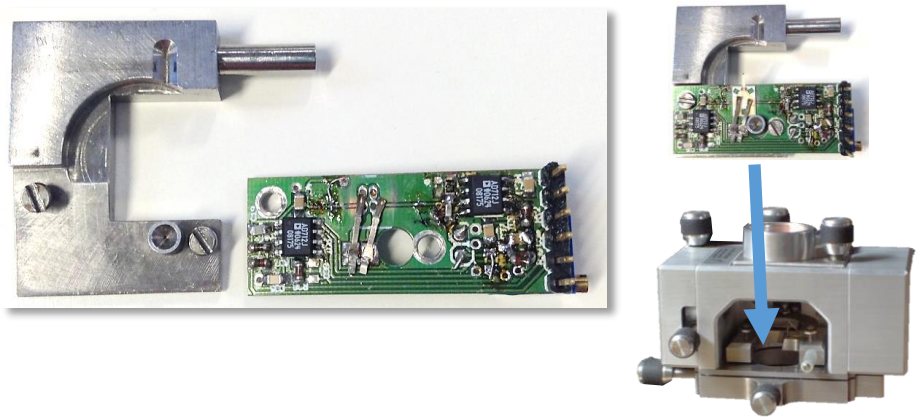


*The silicon cantilever and tip is electrically connected to the left pad of the ceramic plate. In this configuration, the cantilever and tip should have the “virtual” ground potential.

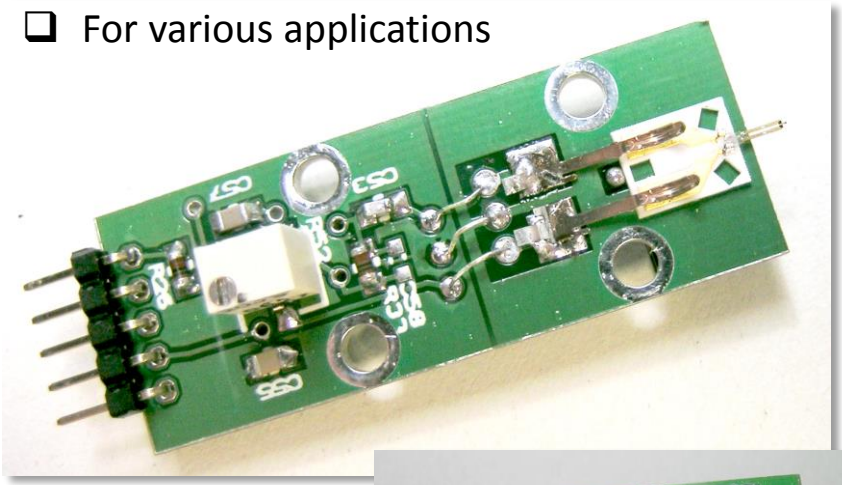
The output amplitude should be about a half, or a bit less, of the input at the resonance frequency. If not, R5 (or R6) should be adjusted. This is also a trimming point when a stable self-oscillation cannot be obtained.

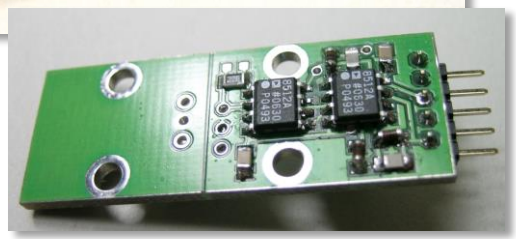
Prototype amplifier boards

- For NanoScope Multimode AFM (Veeco/Bruker) with a custom made holder

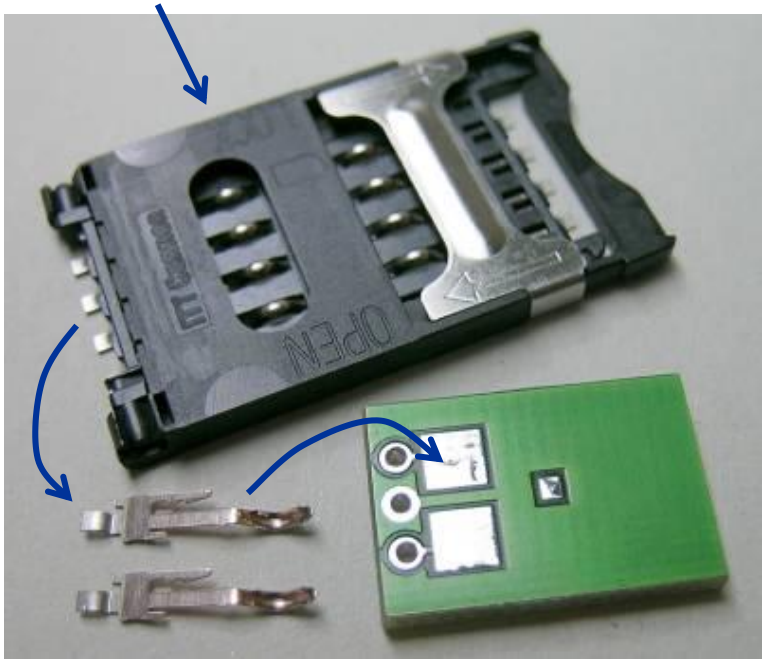


- For various applications



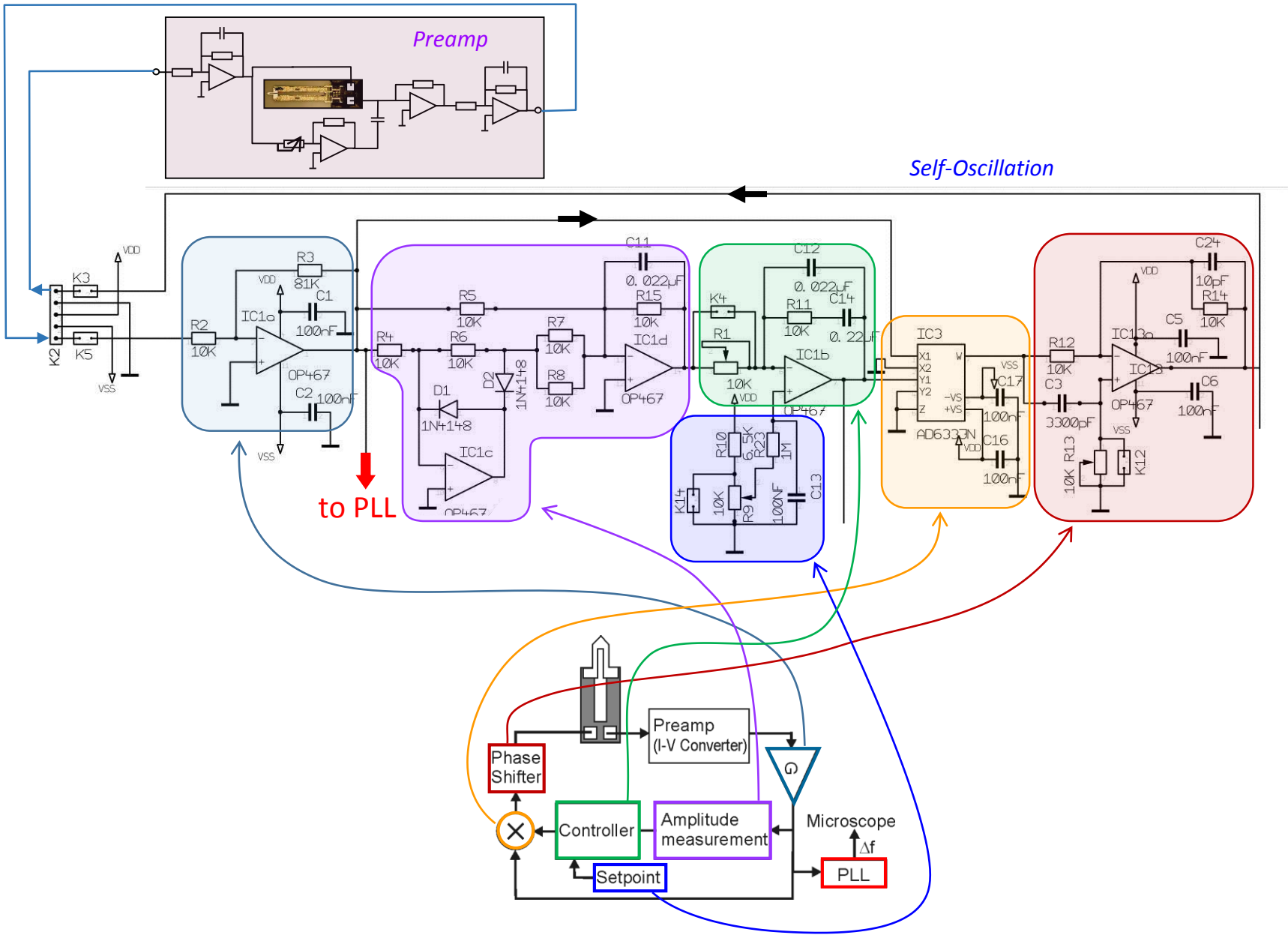


E.g., CONNECTOR, SMARTCARD, 8WAY
CCM03-3003 LFT — ITT CANNON —



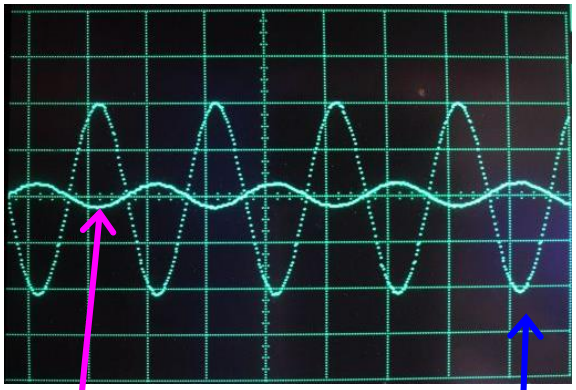
- Spring-pins from a memory card connector, which can be easily pulled out, are used. The metal pieces are soldered on a patterned PCB after cutting off excessive parts.
- As a stopper, a small solder bump is created.
- It is recommended to have a large ground plane to improve stability of the oscillation.

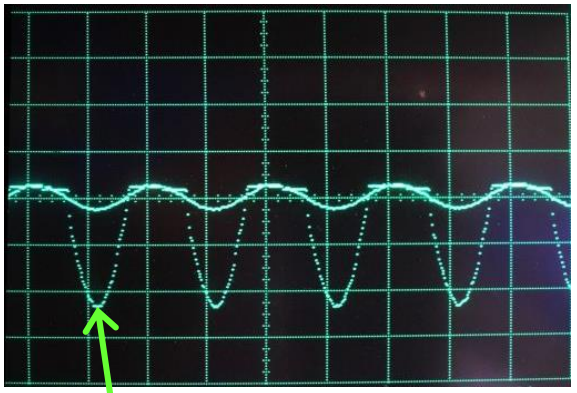
Functions of self-oscillation circuit

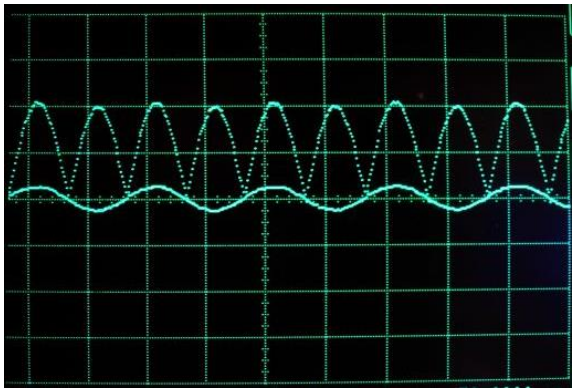


Test of self-oscillation module (1)

10 µs/div, 2 V/div







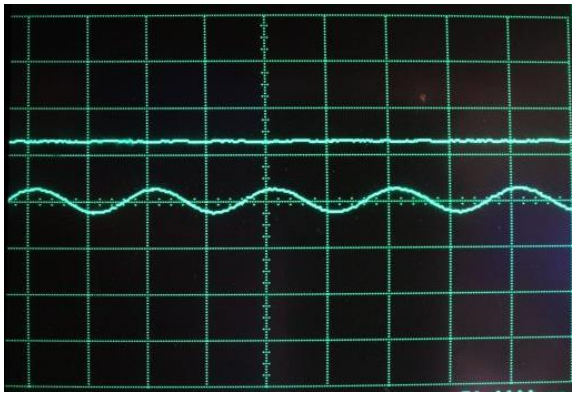
A sine wave of $1V_{p\text{-}p}$ at 50 kHz from function generator

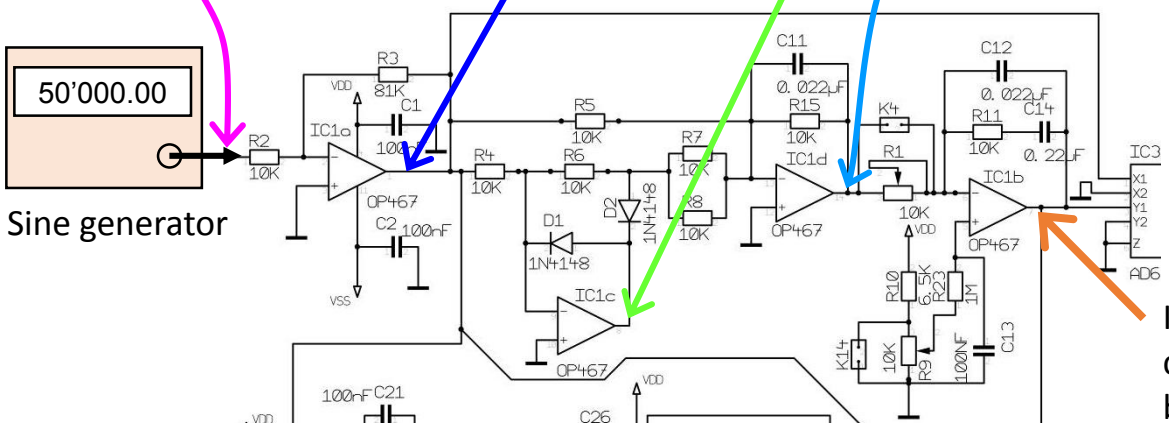
x8 amplification (polarity reversed)

Half wave

If C11 is removed or inserted.

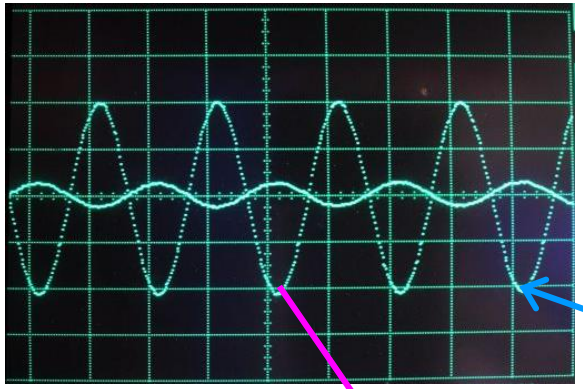
DC





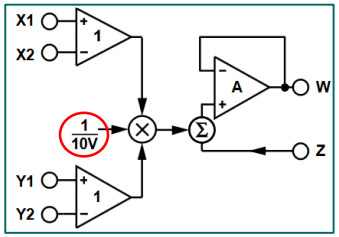
If C11 inserted, C12 removed, C14 short circuit, and R1 ~1.1kΩ, the output signal can be changed +10~-10V DC by R9.

Test of self-oscillation module (2)

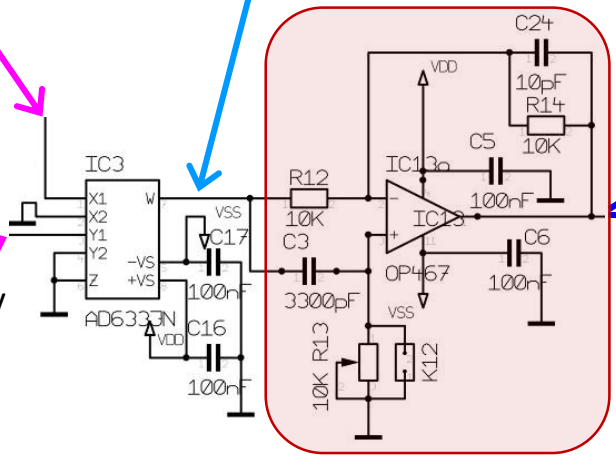


x8 amplified signal

AD633



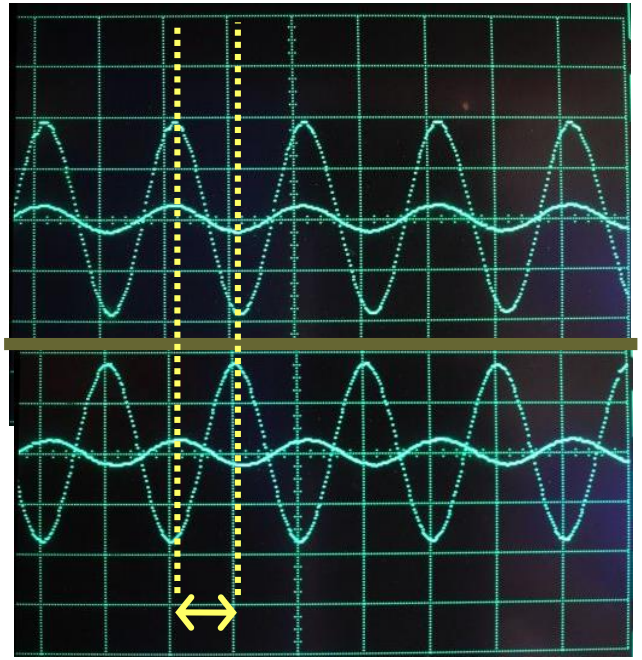
The output is the same signal as X1 when Y1 = 10 V.



Phase shifter

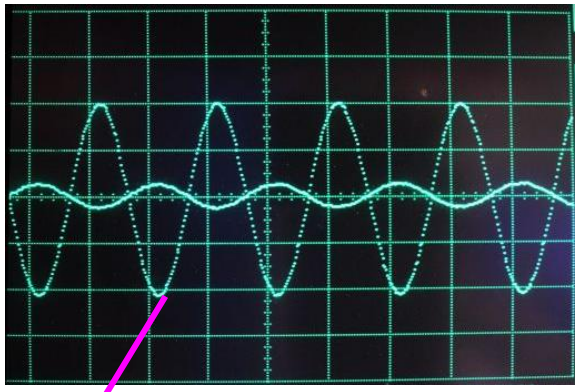
Set signal +10V DC by changing R9.

R13 changes “Phase”. Amplitude is not changed. The figure below shows a tunable range.



10 µs/div, 2 V/div

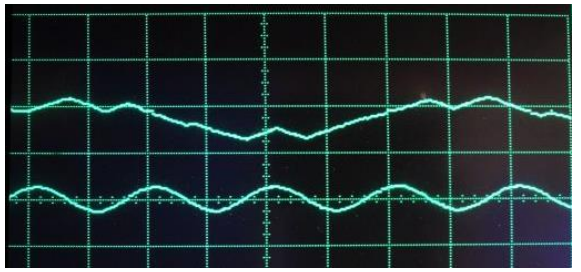
Test of PLL module



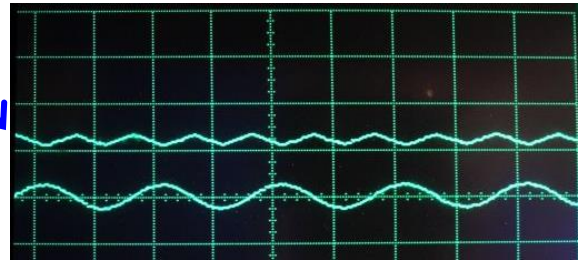
x8 amplified signal

10 µs/div, 2 V/div

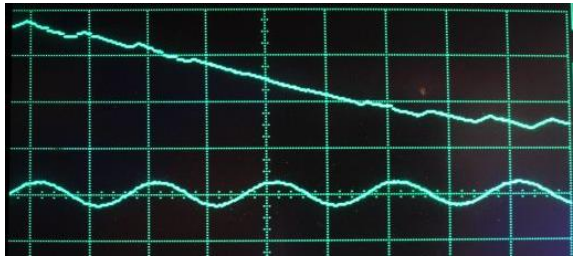
No good

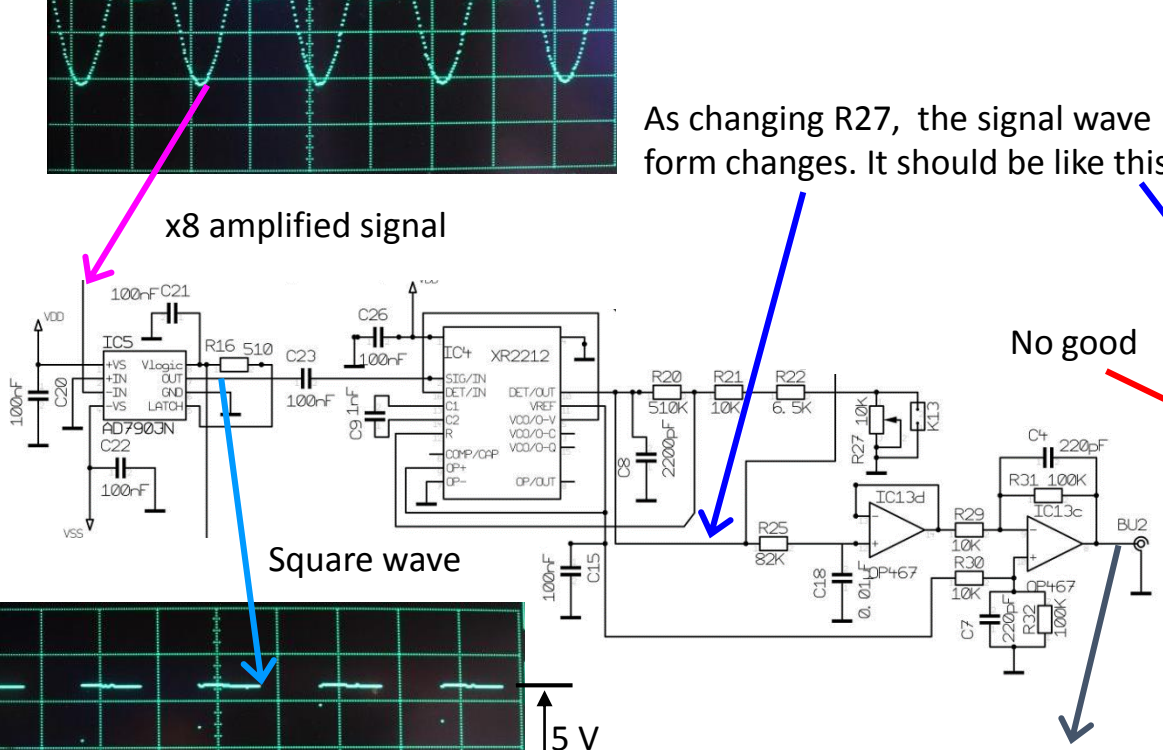


As changing R27, the signal wave form changes. It should be like this.

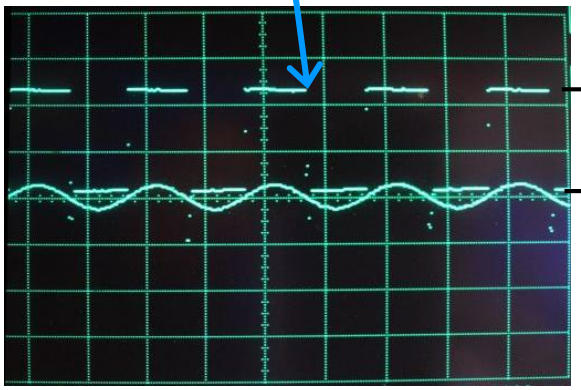


No good





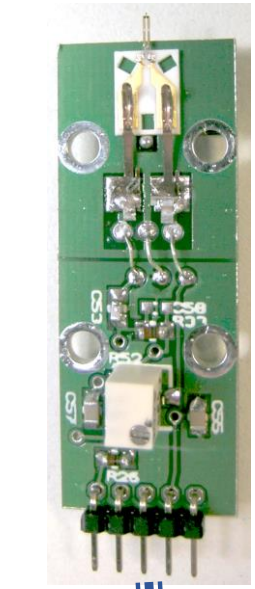
Square wave

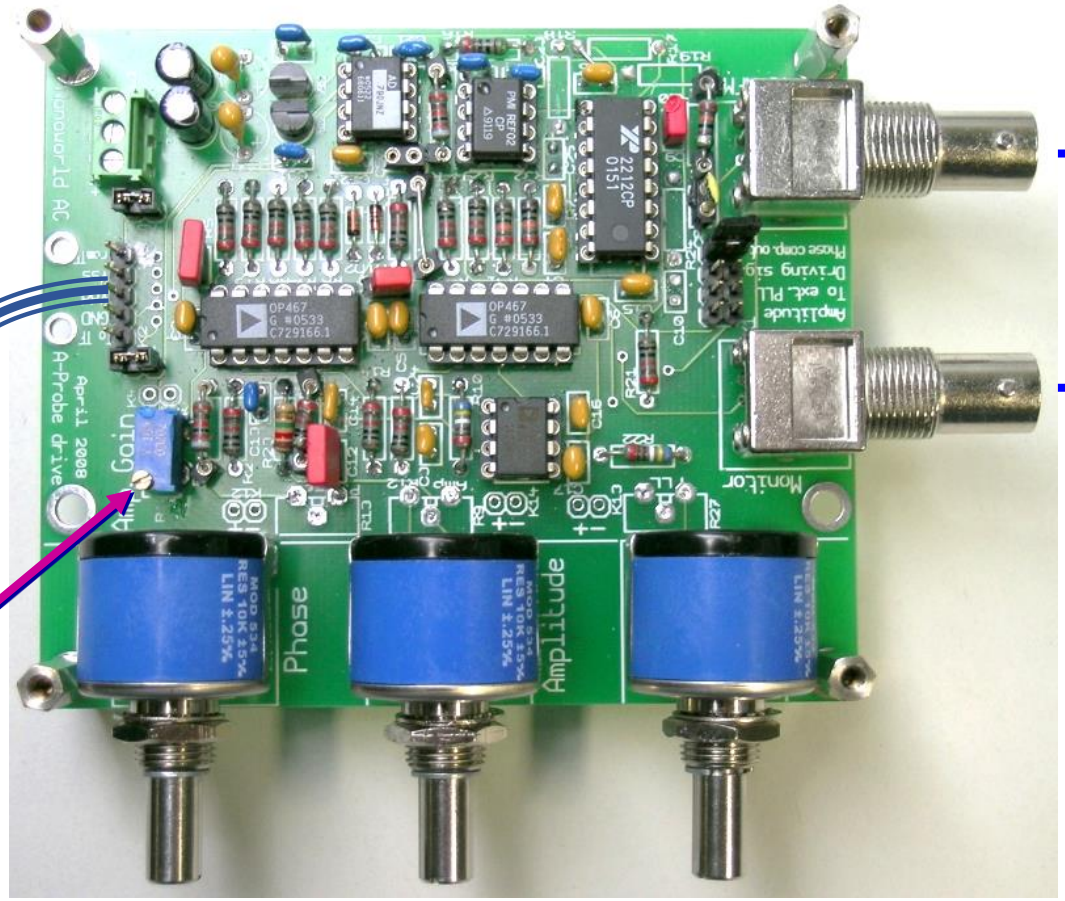


If the signal wave form looks correct and the output at BU2 can be tuned to 0 V by R27, the PLL is correctly set.

To measure frequency sensitivity (V/Hz), change the input frequency a little bit, *e.g.*, from 50.000 kHz to 50.010 kHz.

Overview of the DIY controller





Oscilloscope
(monitor of different signals)

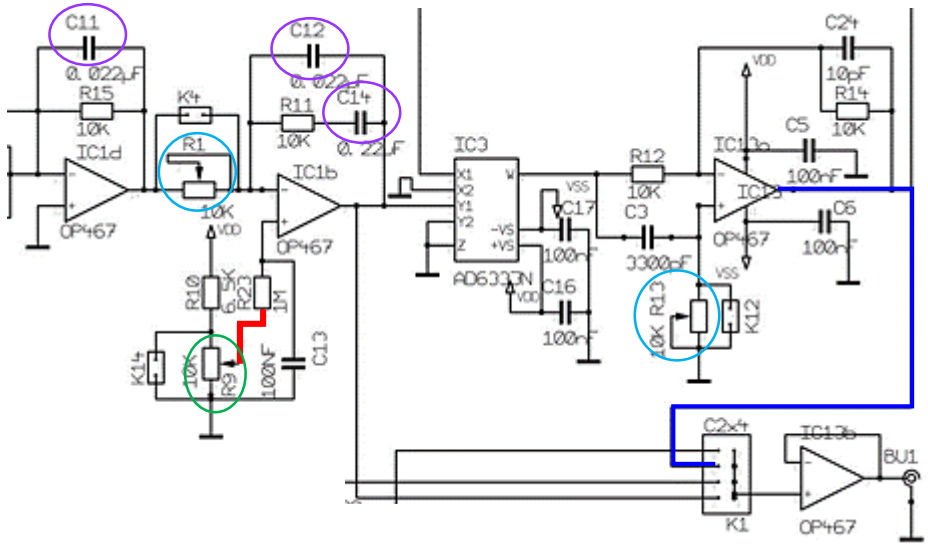
Frequency shift Δf
(to microscope)

Amplitude feedback
gain: R1

Phase: R13 Amplitude: R9 PLL: R27

This controller was designed in 2008 and only bulky components are used. Today, various SMD (Surface Mount Device) are available and the PCB can be much more compact.

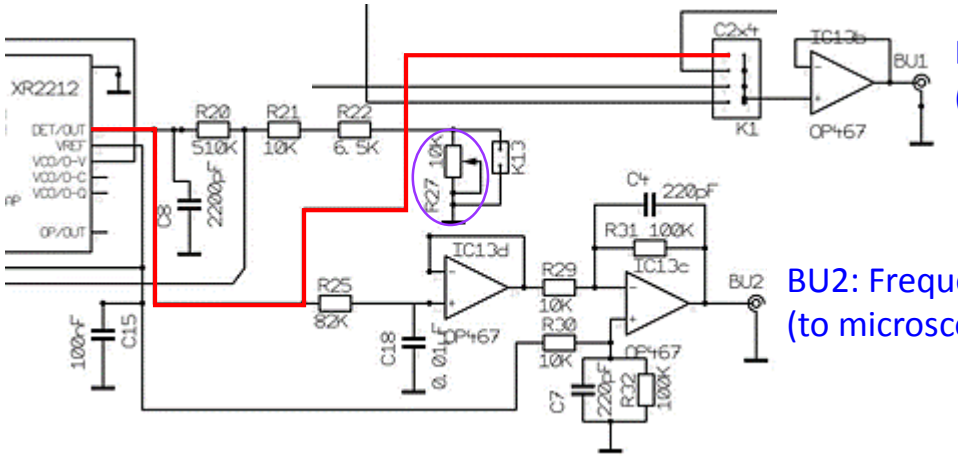
Adjustment of the setup (1)



BU1: Oscilloscope
(monitor of different signals)

- Mount a probe and adjust the trimmer (VR) on the preamp as described in the following slides.
- Make sure that C11, C12, C14 of the main board are all correctly placed.
- Connect the amplifier board to the main board. Monitor the terminal BU1 by oscilloscope. Select the TF driving signal line (output of IC13a).
- Amplitude feedback-loop gain: Set R1 ≈ 2.5 kΩ, Phase controller : Set R13 ≈ 1.5 kΩ,
- Turn on the power. Amplitude: set the line between R23 and R9 ≈ 1.5 V. A sin wave should appear on the monitor.
- Fine-tune the phase adjustment (R13) so that the sin wave has a minimum amplitude.
- The “amplitude feedback-loop gain” (R1) should be set as high as possible, but low enough to keep the signal stable.
- The tip vibration amplitude can be changed by the amplitude adjustment (R9).

Adjustment of the setup (2)



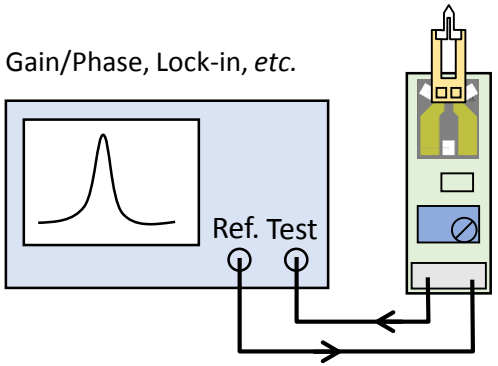
BU1: Oscilloscope
(monitor of different signals)

BU2: Frequency shift Δf
(to microscope)

- Select DET/OUT terminal of XR2212 to appear on BU1.
- Simultaneously monitor BU2 on oscilloscope.
- Turn PLL (R27) until a small triangular wave appears at BU1 and 0V DC appears at BU2.
- The PLL is now correctly set. If the resonance frequency increases, the signal at BU2 also increases.
- If the signal is not stable, change values of the “amplitude feedback-loop gain” (R1) and/or the amplitude adjustment (R9) and try again.
- The self-oscillation frequency should be approximately the same value as the one obtained in the tuning step of the preamp board.

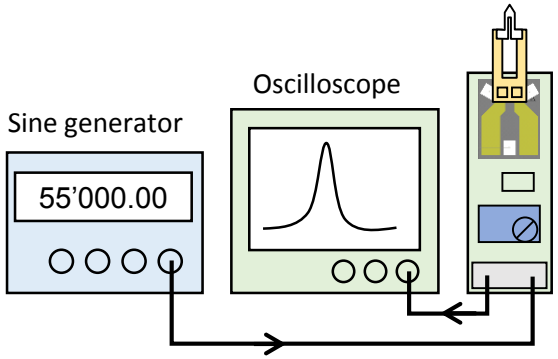
- **Please also consult the other guides from Akiyama-Probe website for successful operation.**

Adjustment of amplifier board (1)



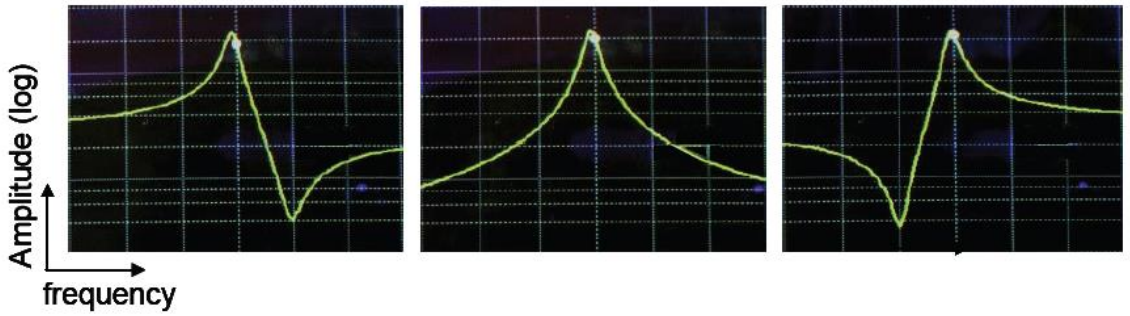
❑ If a parameter analyzer (Gain-phase, Lock-in amplifier, *etc.*) is available.

Find a peak by sweeping the frequency. Adjust the VR (or VC) on the board so that the peak becomes almost symmetric. In this condition, the parasitic capacitance around the probe is mostly compensated and only the piezoelectric current is amplified.

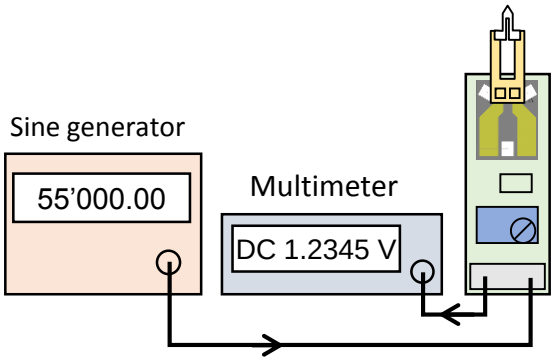


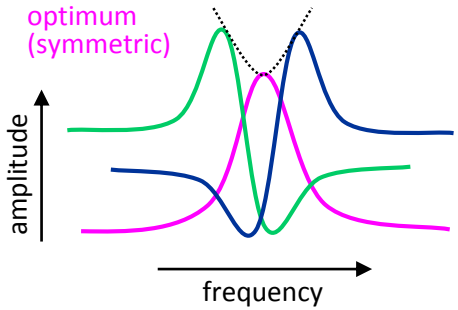
❑ If a sine wave generator **with frequency sweep function** and an oscilloscope are available.

Start a frequency sweep of the sine wave generator: *e.g.*, center frequency = resonance frequency of the probe, bandwidth = 2 kHz, amplitude = 1 V peak-peak, sweeping time = 5 seconds. Set the time axis of the oscilloscope, *e.g.*, 500 ms/div, so that one cycle of the frequency sweep can be monitored. If a peak is found, make the sweep range narrower, *e.g.*, 1 kHz, if not, slightly change the center frequency. Adjust the VR (or VC) on the board.



Adjustment of amplifier board (2)





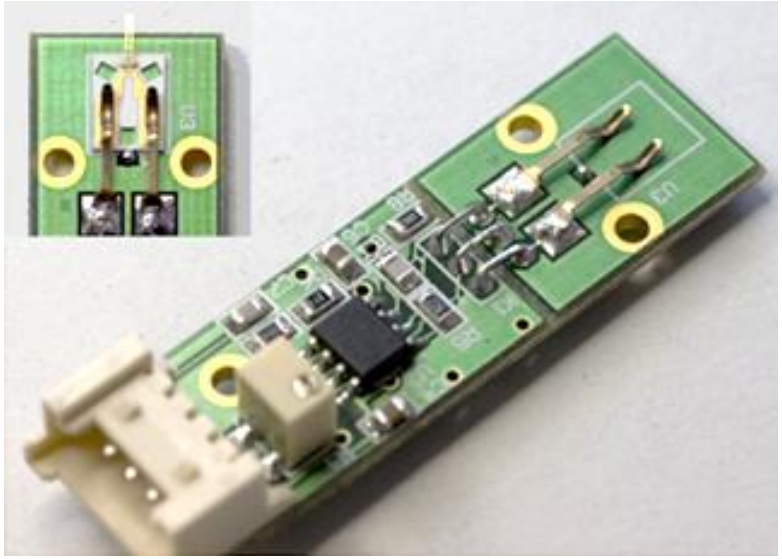
- If a sine wave generator **with NO frequency sweep function** and a multimeter (or an oscilloscope) are available.
  - Set the frequency from the generator at the expected sensor resonance.
  - Precisely adjust the frequency to obtain a maximum amplitude (measure on the multimeter). Take a note of the frequency and the amplitude.
  - Slightly turn the VR (or VC) on the board to one direction.
  - Adjust the frequency and find a maximum amplitude again. Repeat this step if you obtain a smaller amplitude than before. If the amplitude is increased, turn the trimmer to the other direction.

The optimum setting is at the point where the amplitude is at its minimum (see the figure below). Note that the amplitude change is usually very small.

Each time when a probe is exchanged, it is advised to readjust the tuning to obtain the best performance.

Commercial controller

- If a completed controller is desired, please consider to purchase **Tuning Fork Sensor Controller,** commercialized by NanoAndMore.
- Only the preamp + probe holder board (picture below) is also available.
- Other comanies are also selling high performance contollers and PLLs. Please check Akiyama-Probe website.



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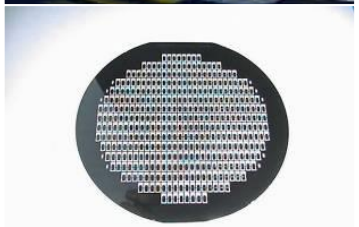
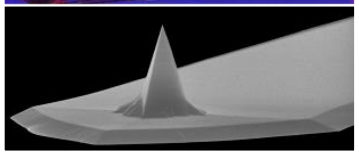
The World of Scanning Probes and More

http://www.nanoandmore.com/tuning-fork-sensor-controller.php

THANK YOU FOR YOUR INTEREST

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