

Document on creating a seismograph.

Draft.

This is a gpu (global distributed computing over a p2p network) project.

The basic idea is to, instead of using the network for distributed computing and use it as global sensor network. Broadcasting (statistics of) sensor data is not expected to require high-bandwidth, and generally broadcasting will be efficient to inform all clients and other nodes, making the data publicly available in real-time!

Possible applications for such sensor data are:

- weather stations
- webcam (** (too) bandwidth intensive)
- seismographic data

Seen practical issues, weather data and seismographic data are very convenient for our amateur network. Since weather data has been done many times before, and amateur weather stations are or not that precise or expensive (barometer, humidity sensor). What we aim is to make a low-budget project. The software should do it, the hardware should be as KISS as possible. I'll try to make this another 10 euro project :)

F.A.Q.

What is a seismograph for?

To measure earthquakes and their location.

So, what is needed to measure earthquakes?

A seismograph, some electronics to pick up the signal, and some analyses, wetter plotted and interpreted by humans, and / or analysed by software.

You're a dutchman. Will you measure any earthquakes in your area?

Not big ones on a regular base, like the americans do. However, we have small earthquakes here, causes by 'sinking land' (holland slowly sinks into sea) and, especially, by pumping gas out of our gas bells (slochteren) which already causes a 10-30 cm decrease of land level. Earthquakes in the neighbour of the Alps i should be able to measure, so are stronger earthquakes (Richter 6 and up) on other parts of the world. This seem to be realistic estimations, and depending on the hardware it may even get more sensitive.

However, if you live somewhere else in the world you are kindly invited to join. If you do not know how to handle a soldering iron, I'd be pleased to send you the electronics. Building the

seismograph is up to you, read on.

Sources

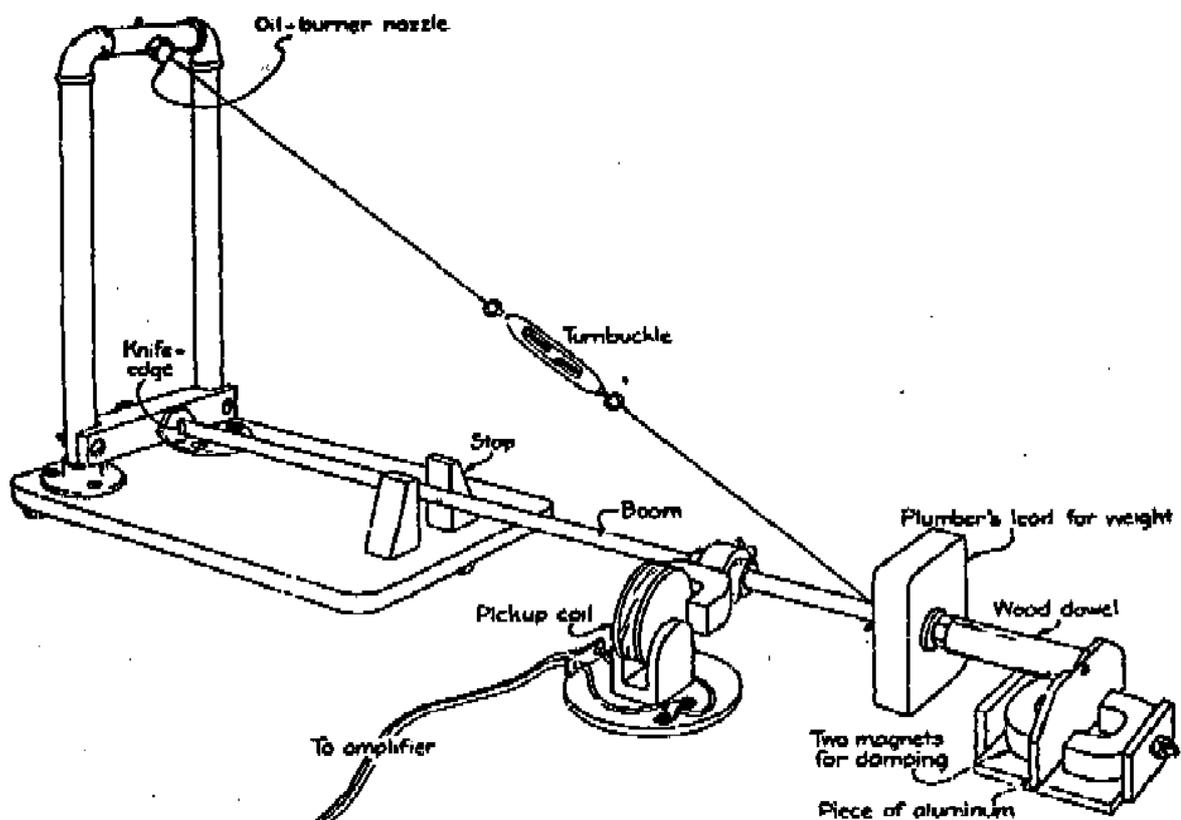
There are several sources on the web, describing how to create a seismograph. It appears earliest amateur models -with high accuracy- have already been built and documented in the 1970's. The basics are real simple. A google query for 'seismograph' or 'simple seismograph' should give you a tonload of relevant hits.

I like to point to this article

<http://psn.quake.net/lehmntxt.html>

that perfectly describes the basics.

This image is from the article mentioned above:



As we see, on a bottom plate a solid U-shaped construction is made. On this construction hangs an arm that can freely move with as less friction as possible.

The electric signal is, in this example, picked up by a coil. I planned to modify that.

On the end is a damper, a piece of aluminium between two strong magnets. Actual moving will generate induction currents. If this was not done, a single shock may cause the arm to move for long times.

What is important. When measuring earthquakes, we want to measure low-frequency signals, typically $< 1\text{Hz}$. We do want to filter out footsteps, passing cars, buses and metro's etc. It is said this is not too hard, because they all tend to create much higher frequencies.

The electronics.

The example above uses a coil to pick up the signal. I think it is not suitable. First, LFO waves have little power, so will create a very low signal. Any filtering will be more difficult. Also, the electronics need strong amplification, and is vulnerable to electric distortions.

What we are actually interested in is the position of the arm. If we can sample its position with any convenient interval ($>1\text{Hz}$, say 100-500Hz) we are fine. The problem lies in the resolution.

What are the options:

Optical.

By mounting a mirror and using a simple laser we might get very nice results. The problem may be with the detection array/camera(web cam?)/whatever. This seems advanced design.

By inductance.

This is the method from the example using a pickup coil, above is explained what the disadvantages are.

Capacitance.

We mount two metal plates close to each other, partly overlapping, one on the arm one on the base. The variable capacitance may be better in picking up low frequencies, since there is no current to flow away. Disadvantages is also electric or other influences. If you move your hand close to the plates it will detect it (your body starts acting as part of the capacitor).

Piezo.

By making the arm not move, but measure the pressure using a Piezo element, we can measure the forces involved. Since it is more or less solid state, piezo may be suitable for other mechanical construction as well, particularly a vertical mounted arm. Or a series in 2 or 3 dimensions on the same arm.

For this project, I'd like to experiment with the last two methods: capacitance and piezo.

In both cases we convert our signal using a variable frequency circuit, controlled by our detector. For capacitance, just because this seems most convenient to measure LFO very accurate and with high resolution. This signal is then fed to a soundcard where software performs further analysis. A microcontroller that does pulse counting should work as well, since the output signal is more or less a perfect square wave.

For the piezo version, because frequency modulation is a perfect 'poor mans' a/d converter. It saves us the a/d converter, with all problems (any a/d converter > 12 bits is expensive). However, I am unsure about the range of the signal as generated by the piezo. There are lots of issues. Also, some current will flow, disturbing our signal. However, if no current would flow the piezo would be able to generate very high voltages, think of the piezo's used in those "electronic" cigarette lighters.

Progress so far.

So far, i have not put together anything physical, that phase is about to enter now. Today i bought some opamps and a handful of capacitors, so that this electronica-n00b can start building the electronics. If electronics is working I'll start building hardware. After that i will start writing the software. Meanwhile i must see if i can get a (wireless) network connection in the basement. Electricity is there.

I've put together two circuits using example schematics and Pspice. They are designed to use 5V but may be (especially) the piezo variant may need a higher voltage range (24V or some). Not sure about this last statement.

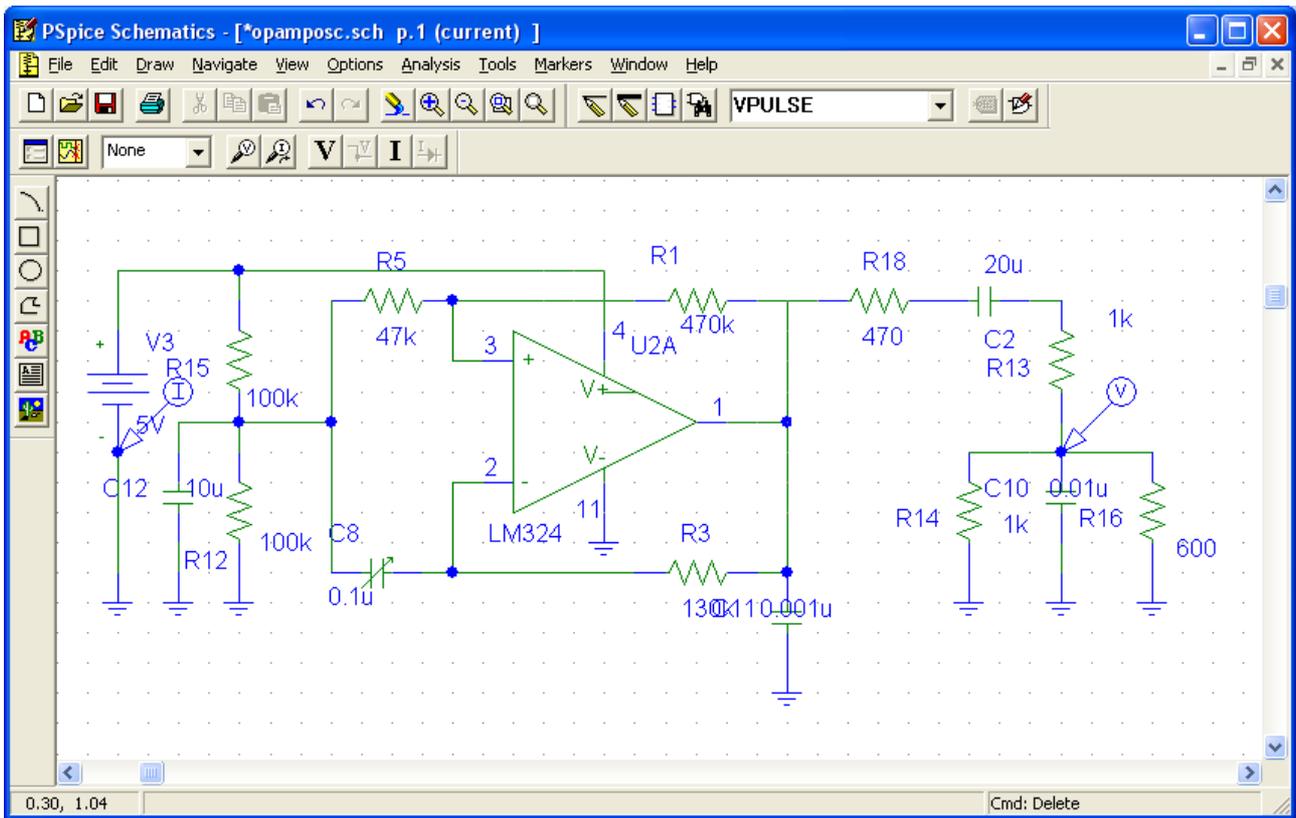
Prerequisites are a computer, 5V from USB or power supply, sound card. The software will be written in pascal, and i will try to use cross platform sound libraries.

Where you see a '600' ohm resistor, this emulates a channel of the soundcard. According to creative, the line-in of (one of their) soundcards is typically 600Ohm – 1kOhm. The actual resistance may be of some influence of the oscillator circuit, but since there would be calibration needed anyhow i think this is no problem, it is just to generate 'real life' results with the Pspice emulator.

The schematics

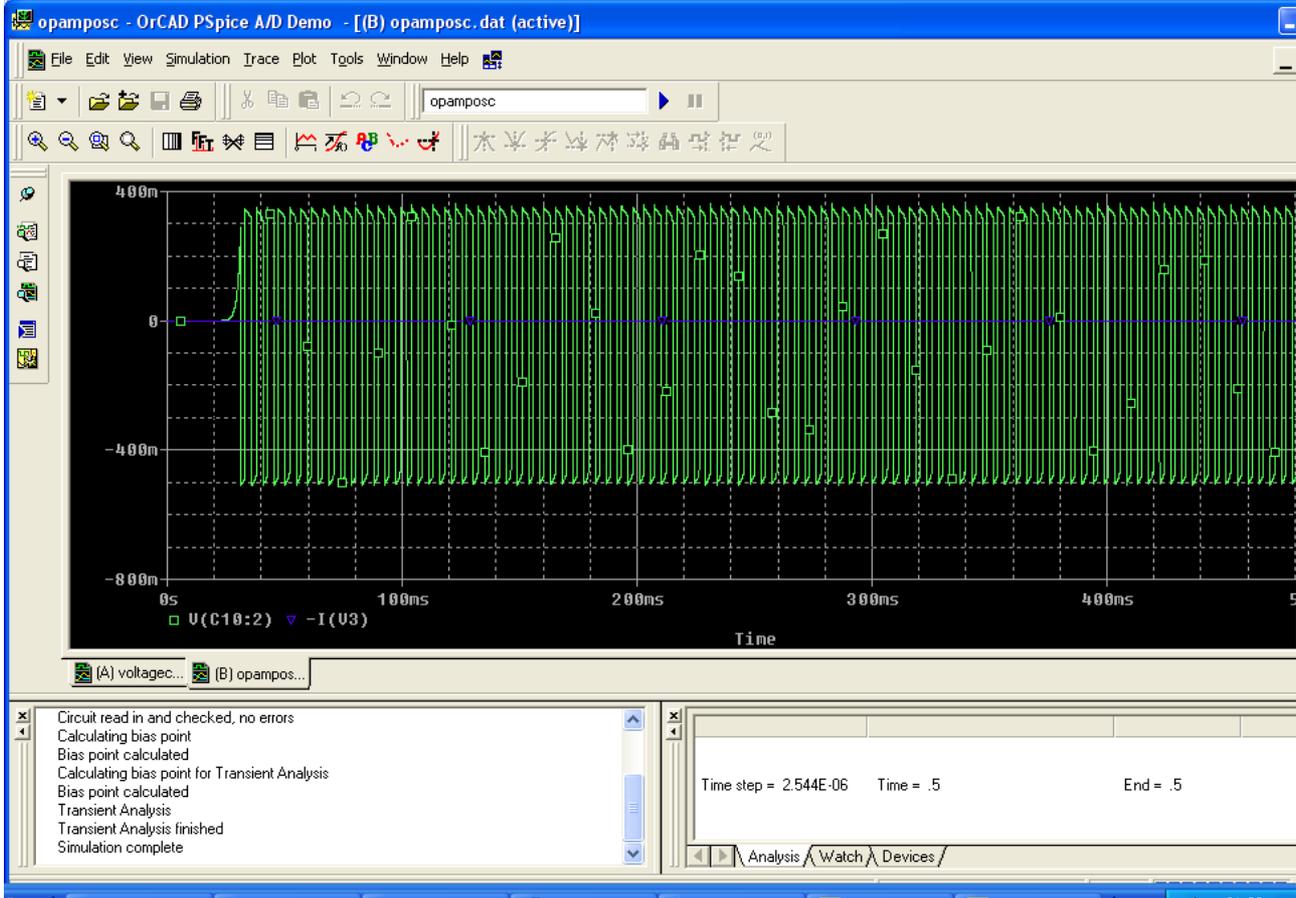
Schematics for the variable-capacitor frequency modulator.

This is a design needing only a single opamp (Operational amplifier). The variable capacitor C8 will result in a variable frequency on the output. A voltage divider is used as artificial ground, this is not needed if we would have a negative power supply.



A sample output from the emulation.

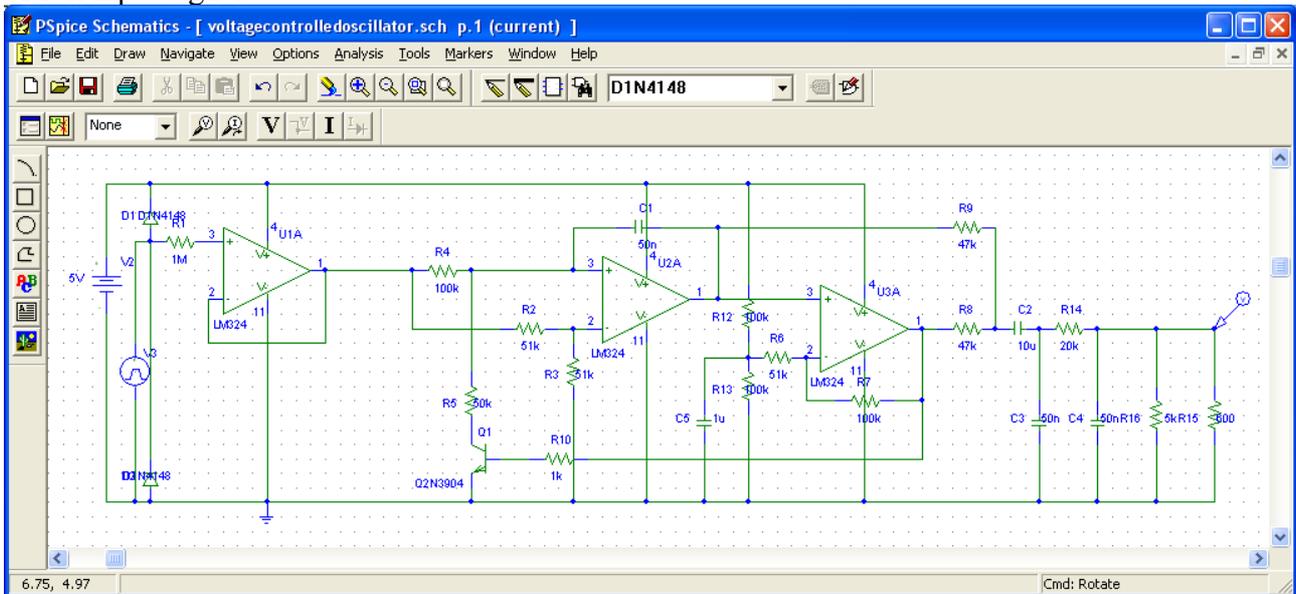
We see it takes quite a few milliseconds before the oscillator starts up.



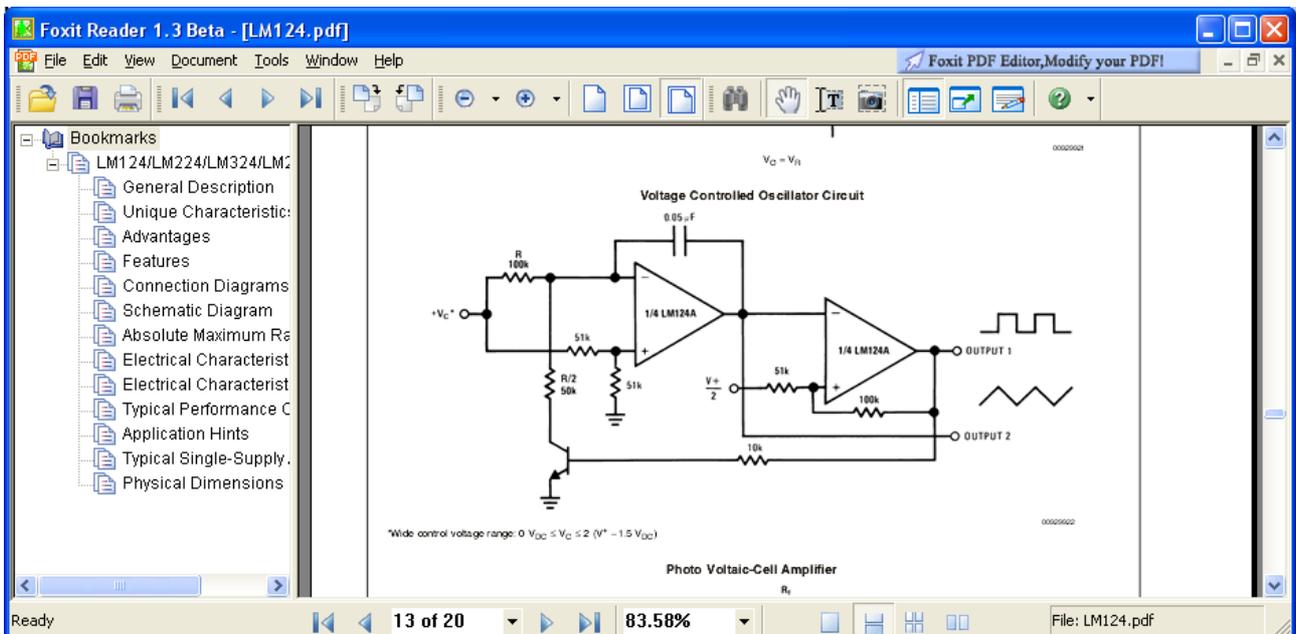
A voltage controlled oscillator

The right 2 opamps are the oscillator circuit

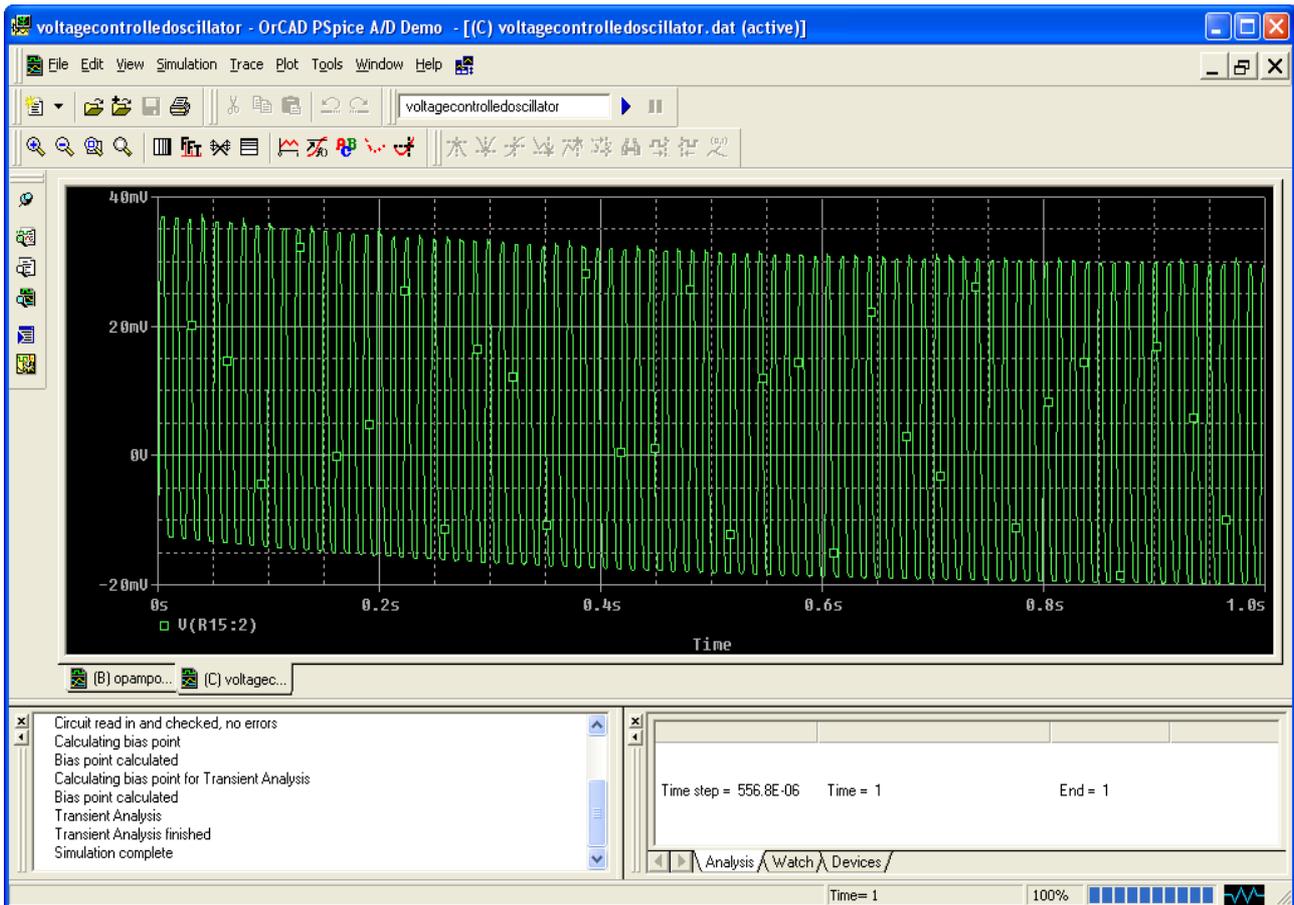
The left opamp is to create a high-impedance input. Two diodes should protect the opamp from out-of-rail input signals.



The oscillator part of this circuit is taken from the LM324 data sheet



And output looks like this:



Notes on above schemes

It may be obvious that those schemes need fine tuning. Particularly, we need to adjust some components (resistors, capacitors) so that we have an optimal frequency range based on what the actual input conditions will be like. This probably will be some trial and error.

Where to get your parts.

I had some at home and got some from a local electronics reseller. However, component resellers are getting less common nowadays (people want gadgets, not lego or electronics. Just like the decadence of the romain empire i imagine).

If you have a company, farnell may be an excellent choice. For hobbyists, conrad is probably most convenient. Conrad can deliver most common electronic parts.

Further reading:

Building a seismograph

<http://psn.quake.net/lehmntxt.html>

<http://cse.ssl.berkeley.edu/lessons/indiv/davis/hs/Seismograph.html>

<http://www.bizarrelabs.com/seis.htm>

How to interpretete the data

<http://vcourseware3.calstatela.edu/VirtualEarthquake/VQuakeExecute.html>

Electronics

http://ourworld.compuserve.com/homepages/Bill_Bowden/opamp.htm

<http://www.ecircuitcenter.com/Circuits.htm>

Pspice

<http://www.electronics-lab.com/downloads/schematic/013/>

http://denethor.wlu.ca/pc300/PSpice/pspice_tutorial.html

Tip:

Read datasheets! Google for “seismograph”, “lm324 datasheet” or “lm741 datasheet” for example