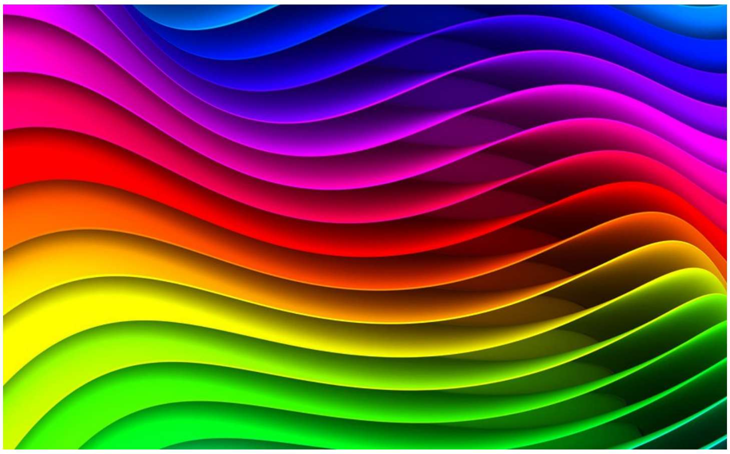
theremino System



Theremino Spectrometer Light sources

Light source for calibration

For periodic calibration checks, it is a good idea to equip yourself with a compact fluorescent lamp (so-called energy-saving lamps). These lamps have two mercury lines perfect for calibrating.

This lamp should be low-powered (a few Watts maximum, otherwise it gets too hot) and should be enclosed in an opaque cylinder (black tube internally coated with white or reflective material) so as to direct the light forward and avoid being dazzled during calibration.

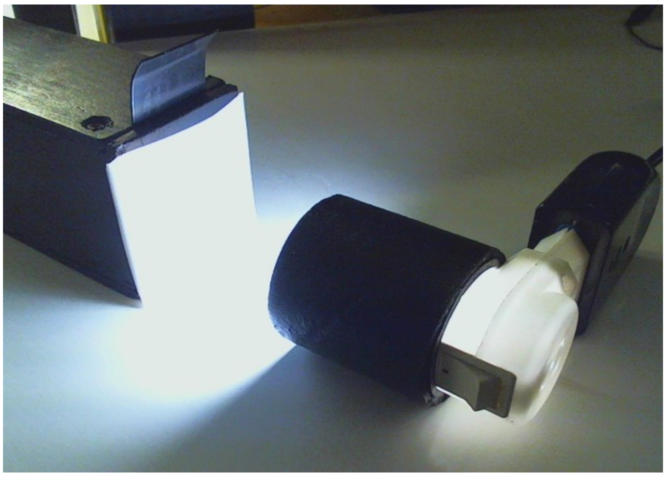
The lamp you see here on the left consumes only 1 Watt and heats up very little. You can find it on eBay for less than 3 Euros, shipping included.

Search for "Night Lamp with Plug", there are other models but be careful that it is not an "Incandescent" or "Led" lamp. Make sure it is "Fluorescent"

Or look in a supermarket for an energy saving lamp of a few Watts, 2 or 3 Watts at most.

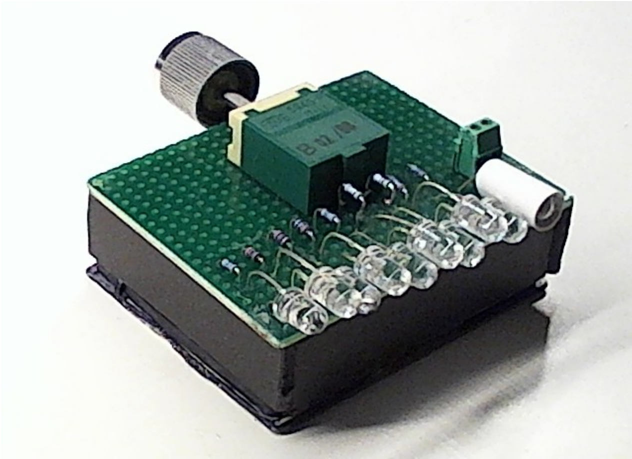
The lamp on the right is 3 Watt, you can find it on eBay by searching for "Fluorescent 3W" or in supermarkets. It exists both with a small connection (E14) and with a large connection (E27)

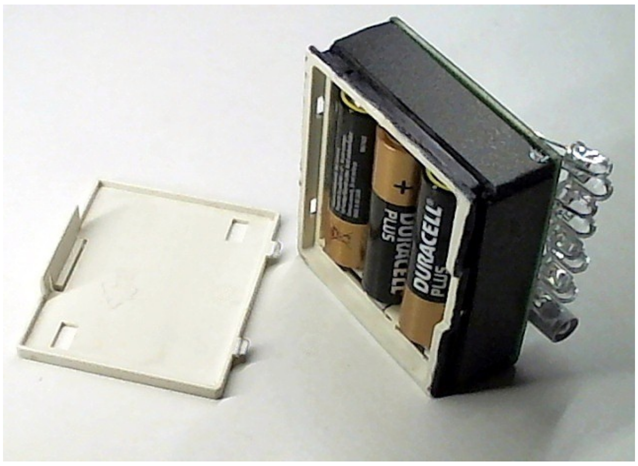
Be careful that sometimes they write "Fluorescent" but then it turns out that it is a "LED" lamp, like the one in this image. Read the entire ad carefully, paying attention to the word "LED".



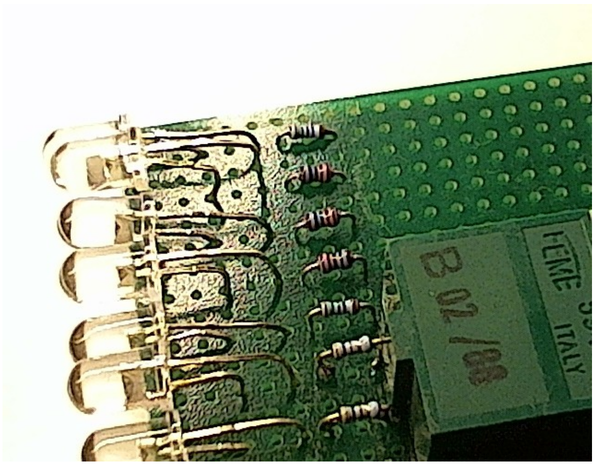
Test light sources

To fine-tune the spectrometer and improve its resolution, it is useful to have light sources with different wavelengths.





With a battery holder, three AA batteries, a switch and some LEDs you can build a very useful little device. Don't underestimate it, with this little device everything becomes easier.

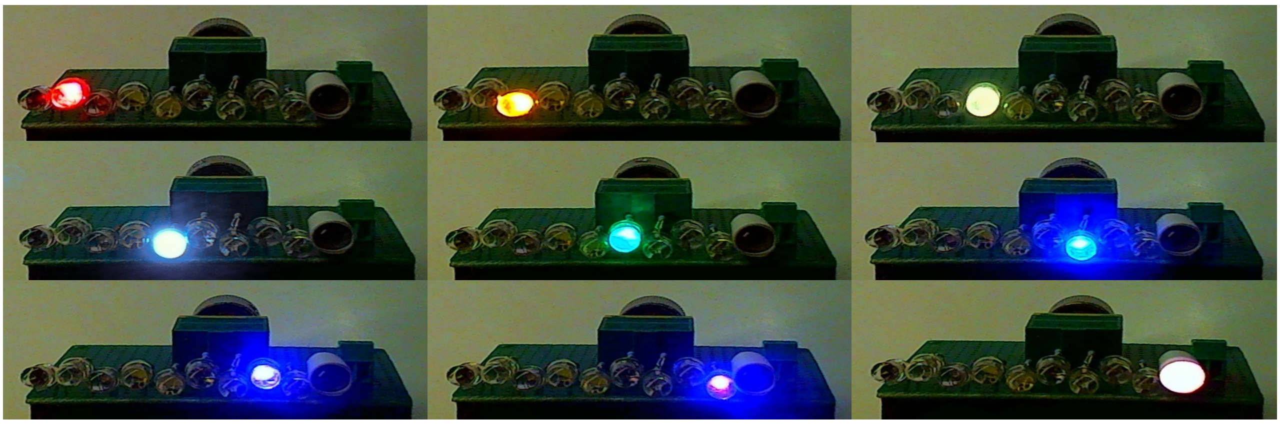


Here you can see a detail of the resistors (one for each LED) and the 12-position switch.

As LEDs you can use whatever you find. In this example the LEDs are: Infrared, Red, Amber, Warm White, Cool White, Green, Blue, Ultraviolet at 407 nm, Ultraviolet at 395 nm and a 150mA 6Volt filament bulb.

The LED resistors are 100 ohms but some have been raised to 150 and some to 220 ohms to roughly equalize their peaks in the spectrum.

The height of the LEDs from the table top should be approximately the same as the entrance slit of the spectrometer. The entrance slit should be covered with the diffusion filter otherwise the position of the LEDs becomes too critical.



The first LED on the left is the infrared one and has not been turned on in these pictures.

Light sources for absorption measurements

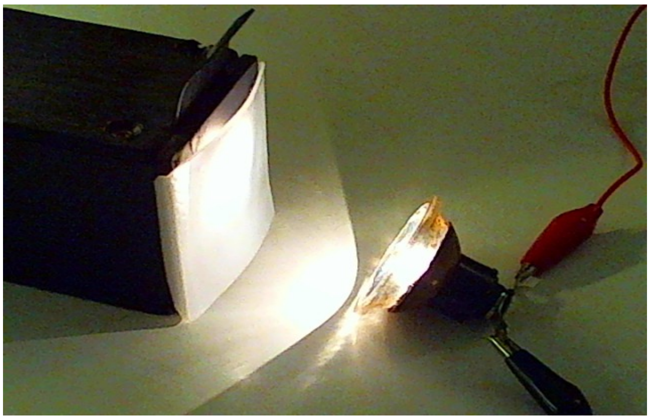
Absorption measurements are used to measure the response curve of colored filters and the absorption of various substances, such as olive oil.

To measure absorption, you need a source that emits light across the entire spectrum. Sources of this type are called "Broadband".

A "broadband" source does not have to have a perfectly flat spectrum (the software compensates for variations when you press the "Reference" button) but it must provide enough light energy across the entire area of interest.

The energy ratio, between the areas where the source emits a lot of energy and those where it emits little, must not exceed 2 or 3 times, otherwise the reflections caused by the areas of high energy cover those of low energy and it becomes impossible to measure strong attenuations. (in the areas where the lamp emits little the line never goes to zero even if the filter under measurement which attenuates those wavelengths a lot)

A "broadband" source should cover at least the visible range (from 400 to 700 nm) but even better if it covers the entire measurable range (from 350 nm to approximately 950 nm)

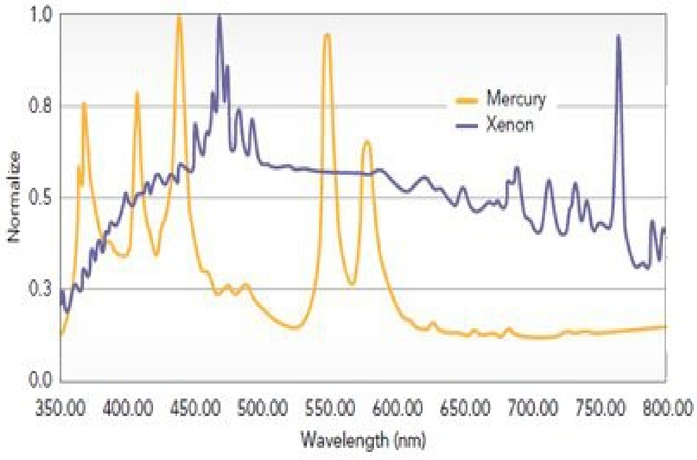


With an incandescent light bulb you go from 500 nm up to infrared but the energy below 450 nm is very little and there are notable differences in intensity between the various areas of the spectrum.

With a halogen you get a little lower but the energy around 400 nm is still a small fraction of that in the red region.

To cover the entire spectrum from ultraviolet to infrared, we could use xenon lamps.

Xenon lamps produce fairly uniform energy from 400nm up to 800nm

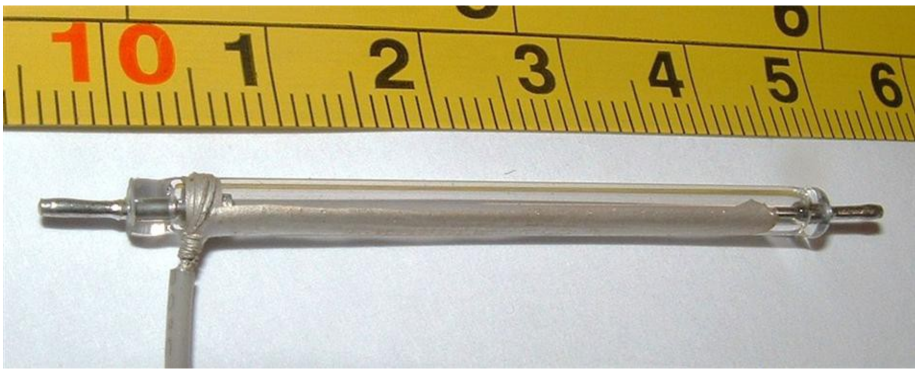


Xenon broadband sources

By modifying xenon lamps from strobe devices (about ten euros on eBay, including shipping) or from the flashes of old disposable cameras (a few euros on eBay), we can avoid giving 934 dollars to OceanOptics (418 dollars for the replacement bulb alone)

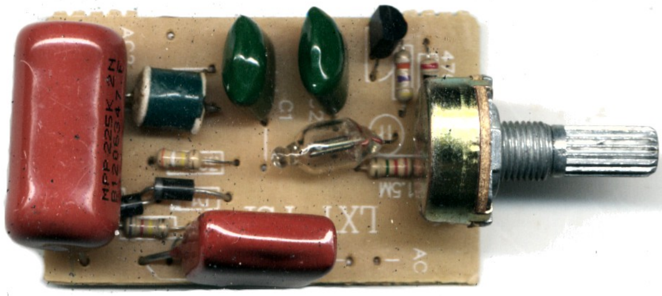
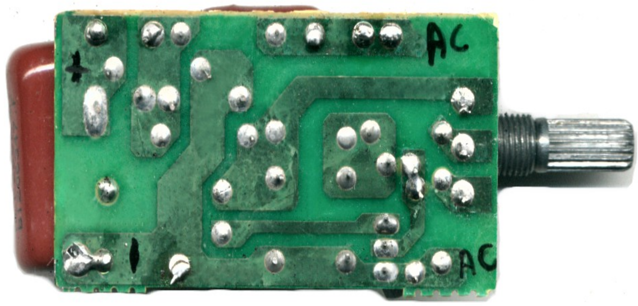
Of course an OceanOptics (http://www.oceanoptics.com/products/px2.asp#output) has more powerful features, reaching over 200 Hz of repetition and 9.9 Watts, while we will be satisfied with 50 Hz and 3 Watts (which in practice are just as good).

All other features are very similar. The working principle is the same and the light from the few euro Xenon bulbs is the same as the $418 ones.

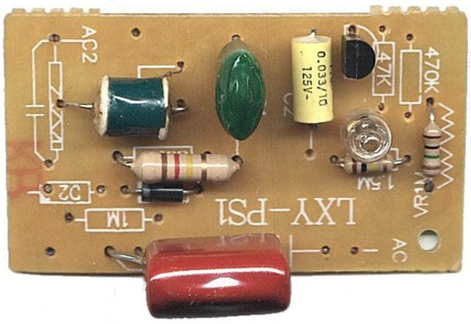


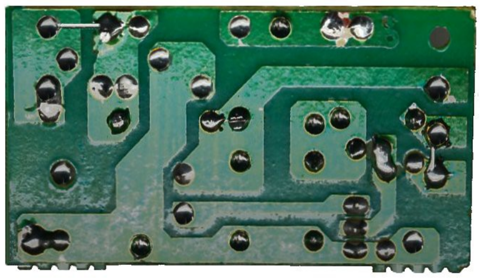
Notice the conductive gray paint covering the trigger wire and extending along the length of the lamp. Be careful not to over-tighten this wire, as the paint may crack. This will cause it to spark in the breaks and the flashes will become unstable.

Xenon source obtained from a Strobe

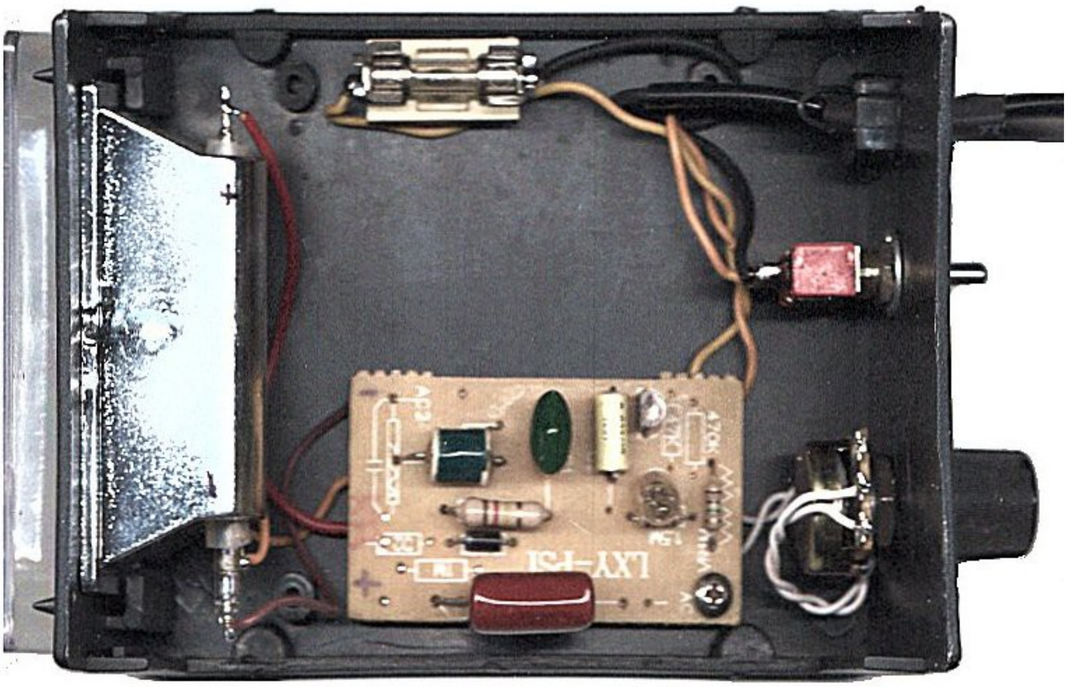



In the original circuit the potentiometer regulated the frequency of the pulses, but it was not possible to exceed 8 or 10 Hz. (the electrical diagrams are on the next page)



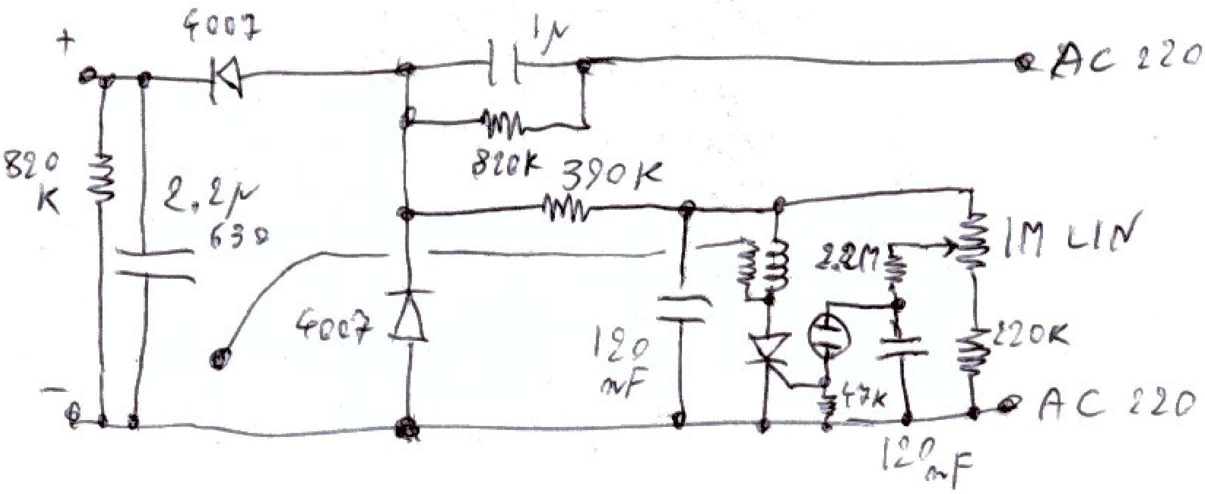


The modified circuit flashes at a fixed 50 Hz and the potentiometer adjusts the intensity of the light produced. The new version is simpler and some components are left over, useful for other creations (mainly the large capacitor on the left 2.2 uF / 250 Volt ac)

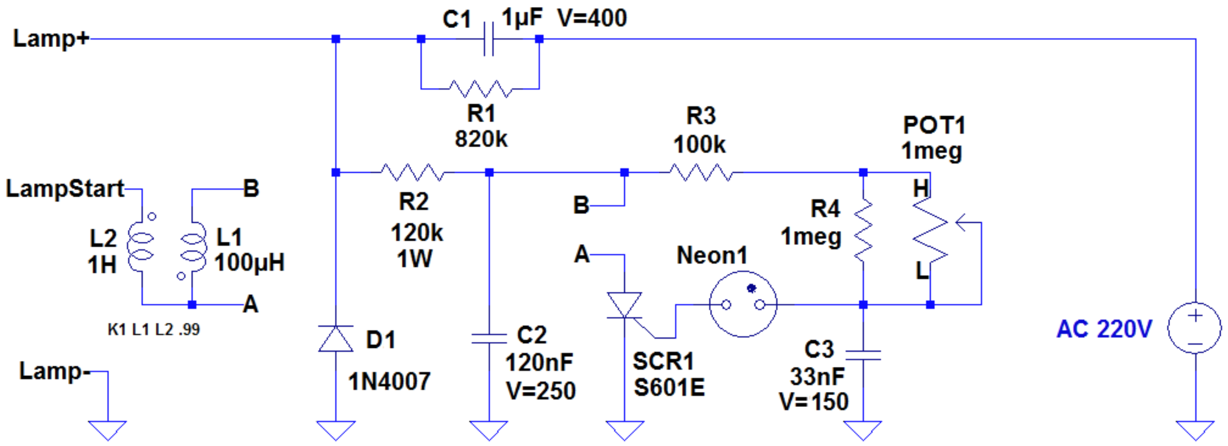


While we're at it, it's a good idea to secure the circuit with a screw (originally it was hanging from the potentiometer rather unstable). Also add a power switch and a fuse holder. A 1 amp fuse will do, but you could try going down to 200 mA.

Xenon source from a Strobe - schematics



Original diagram: The maximum frequency was 8Hz and the energy of the flashes was unstable, because the flashes were not synchronized with the 50Hz of the electrical grid.



Modified scheme: The flashes are synchronous with 50Hz and the potentiometer regulates the intensity of the light produced.

R2 regulates the driving voltage of the starter transformer and therefore the voltage on the "LampStart" wire, with 120k you have about 180 Volts on the transformer and a few thousand volts on the lamp. If the brightness is very unstable you should lower R2 to increase the voltage, but the noise increases significantly and there is also the risk of exceeding the maximum tolerable voltage. If the transformer or the wires spark the stability gets worse instead of better.

Without the 2.2 uF capacitor, the energy reserve is a third (1 uF instead of 3.2 uF total) but since the flash frequency is about six times higher, the average power should increase from the original 2 Watts to about 4 Watts. But in practice it only gets to 3 Watts, due to the increased series resistance. It would have been easy to increase the power even more, but it is best not to overdo it, so as not to overheat the lamp. (and be careful because it gets very hot, never touch it with your fingers, not even when it is cold)

Xenon lamps are always very unstable by nature and even the best ones vary in intensity from one flash to the next. By adjusting the potentiometer you can find positions that make the light more stable.

Here are the simulation files: StroboDriver_Original.asc and StroboDriver_600V_50Hz_Final.asc
To simulate you need LTSpice and our component libraries:
http://www.theremino.com/downloads/uncategorized#ltspice