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Sensors Technology

Basic electronic circuits – analysis and sensing applications

Lab excercises

Smilen Dimitrov

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1 Introduction

With this sheet, we begin our lab excercises in sensors technology. Therefore, we will first get acquainted with the tools at our disposal - and then we will proceed with implementation of some of the circuits discussed in the corresponding part of the lectures.

2 Knowing your 'bench'

In all laboratories in IHK, the tools are typically grouped around a single desk - this is known as a lab place ("lab plads"), aka a 'bench'. A typical IHK lab bench is shown below:

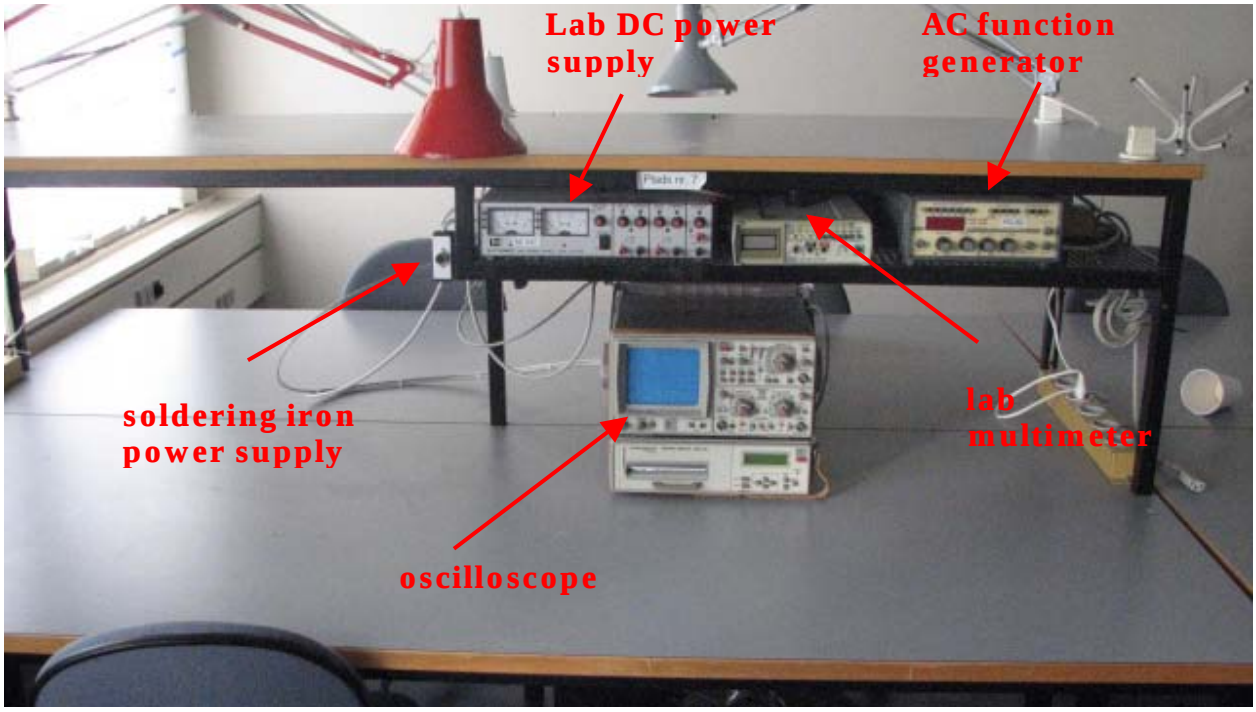


Figure 1.A close-up of a typical IHK lab bench; having an oscilloscope, lab DC power supply, lab AC function generator, lab multimeter, and a power supply for the soldering iron found in the laboratory kits

At this time, we are going to work only with the DC power supply, the oscilloscope and the soldering iron. In this document, we are going to use a portable multimeter instead of the laboratory one, and also, we will not need to use the AC function generator for now.

2.1 The DC power supply

A typical lab power supply on an IHK bench is shown below.

Figure 2. A typical lab DC power supply with 3 independent voltage sources

Note that there may be different types of DC power supplies, depending on in which lab you are. However, for all of them it is common that they have at least two independent power supplies built in: the power supply shown in the figure has three independent (single) power supplies, marked A, B, and C on the image. Each of these sources has

their own + and - connectors, which are also color coded in the standard manner - black for -, and red for +.

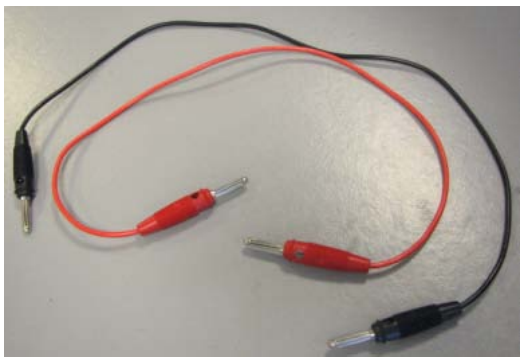
Two of these sources have variable voltage - A and B can have their voltage changed by changing the corresponding "volts" rotary knob. The voltage source C is fixed at 5V voltage. All of the power sources have a current limiter as well (the "current" rotary knob) which helps limit the current that flows in the case of a short circuit (which is why these lab power supplies can generally handle a short circuit) .

Finally we have the "meters" rotary knob, which allows us to specify what it is that we see on the displays on the left. This particular kind will either show us the voltage of power supplies A and B; or the currents given by power supplies A and B; or the voltage (which should be 5V all the time) and the current of power supply C.

So, to get started:

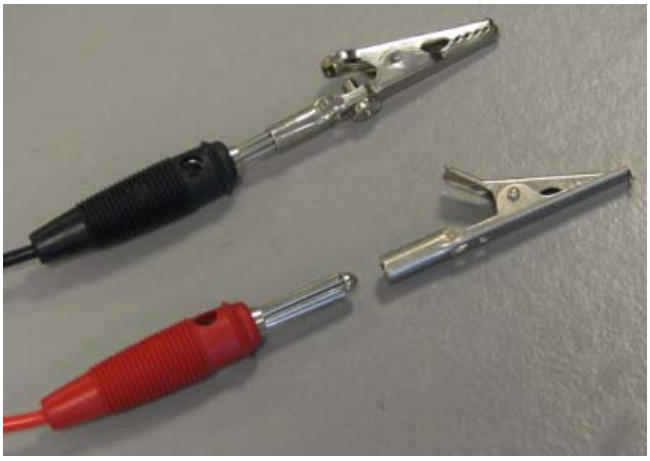
1. Get a pair of cables from the laboratory kit

You may want to take a red and a black one, to keep the power supply color coding.



2. Take a pair of crocodile clips, and attach them to the cables.

This will assist us to attach wires from circuits to the power supply.



3. Attach the free ends of the cables (without crocodile clips) in the corresponding socket (by color)

4. Turn the power supply ON. You now have power supplied in the cables.

NOTE: Before you turn the power on, MAKE SURE that the free part of the cables (with crocodile clips on) are NOT touching - otherwise (if they are) you will short-circuit the power supply !

You may notice now, that on the above image, the left indicator shows either 5V or 25V; here we should realise that the left meter actually does not show the voltage of power supply A, which we are using - as the 'meters' switch is set to show 'C'.

So, as a final step:

5. Make sure that the you are seeing the proper measurement for the desired power supply (in this case A).

We can now observe that the left meter shows around 11 V, which should be right. Try changing the 'Volts' knob of power supply A, to see if the meter changes as well.

Right now, there is not much else we can do with the power supply, so you may turn it off.

The next step will be to measure the voltage of the power supply with an oscilloscope.

2.2 The oscilloscope

A typical oscilloscope found in IHK labs is shown below:

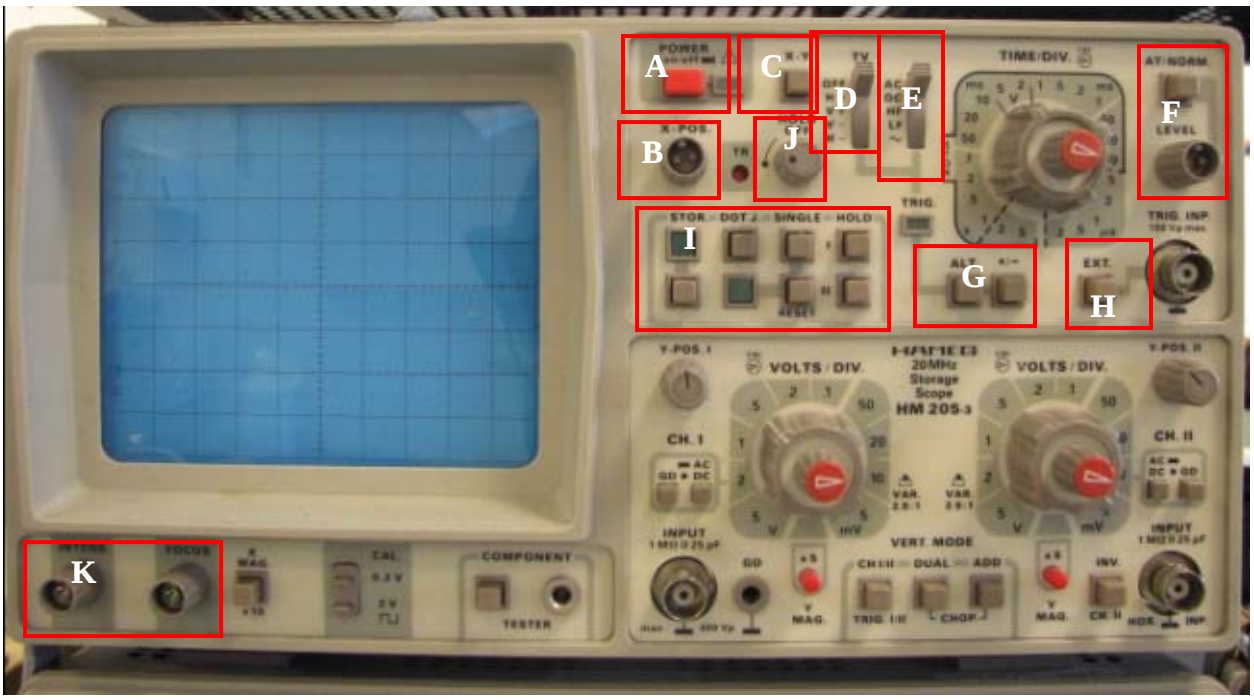


Figure 3. A typical oscilloscope (Hameg) found in IHK labs

Description:

A - Power switch
B - x position of the beam
C - X/Y switch: "If the 'X-Y' button is on, the horizontal deflection (X) of the electronic beam drawing the curve is not controlled by the sawtooth generator of the oscilloscope but by the signal attached to channel 2. The vertical deflection (Y) is determined by the signal attached to channel 1. Both input signals can be added if needed ('Add' Schalter), so that the sum of both channels can deliver the vertical signal. [1]"
D - TV trigger switch : "With the 'TV Sep.' button a triggering using picture- and line-synchronizing impulses of monitors or TVs are possible. The abbreviation means as much as 'active TV synchronizing separator'. It makes finding errors on TVs more simple. If the switch is set to 'Off', picture- or line-synchronizing impulses do not influence the trigger timing. In position 'TV H' the trigger time is determined by the sart of a new picture, in position 'TV V' it is determined by the start of a new line of the picture. [1]"
E - Trigger coupling switch: "The 'Trig.' switch is used to configure the trigger coupling. In position 'AC' (alternating current coupling) the trigger signal is RC-coupled. Its direct current component is filtered. This means that signals, which have a frequency lower than the lowest frequency the oscilloscope allows, cannot be triggered. In this simulation however there is no low frequency limit. In position 'DC' (direct current coupling) all signal components starting at 0 Hz influence triggering. In position 'HF' (for 'high frequency'), low frequent signal components are filtered, in position 'LF' (for 'low frequency') high

frequent signal components are filtered. These positions are used to filter noise. Noise amplitudes can trigger unwanted sweeps. [1]"
F - AT/Norm and Level - "Using the 'At./Norm.' button you can switch between automatic trigger level selection (At) and normal, manual trigger level selection (Norm.). The trigger level in automatic mode equals the level during groundline crossing, in this simulation that is 0 V. The trigger level in manual mode can be set using the 'Level' wheel located below the 'At/Norm.' button. Using that wheel, voltage values larger than the amplitude of the signal can be set, too. However, as the signal level will never reach that (higher) trigger level, the signal will not be triggered in that case at all. [1]"
G - ALT and +/- switches - "The '+/-' button determines whether a signal is triggered on ascending flank (+) or descending flank (-). If the button is off, the ascending flank is used, otherwise the descending flank is used. This setting is independet from manual or automatic trigger level setting (independent from the 'At/Norm.' button and the 'Level' wheel). [1]"
H - EXT button - "When the 'Ext.' button is on (='external'), the trigger timing of a real oscilloscope is not determined using the signal from channel 1 or 2 but from a signal attached to the external trigger input connector. [1]"
I - Signal snapshot storage section
J - Hold Off button - "The 'Hold off' wheel determines the time that passes between the end of a sweep and the start of the next sweep. The expression is derived from the invisible ('off') beam and to 'hold' it in that situation. [1]"
K - Intensity and Focus buttons

When working with an oscilloscope, first and foremost we have to remember that it measures **voltage**, that is **potential difference**. That means that we always measure the potential difference *between two points* in a circuit.

Oscilloscopes usually offer possibilities to trace signals from two individual channels. In this case, we are going to measure a single voltage (the one of the power supply) so correspondingly, we are going to use only one channel. However, we again need to remember that one channel corresponds to one voltage - that is, on one channel we measure the potential difference between two points in a circuit.

In order to start measuring, we first need to connect an oscilloscope **probe** to the corresponding channel input. We can find two probes in the IHK laboratory kits - the image shows one of them.

Notice that the probe has a probe tip, probe ground clip, and a BNC connector.

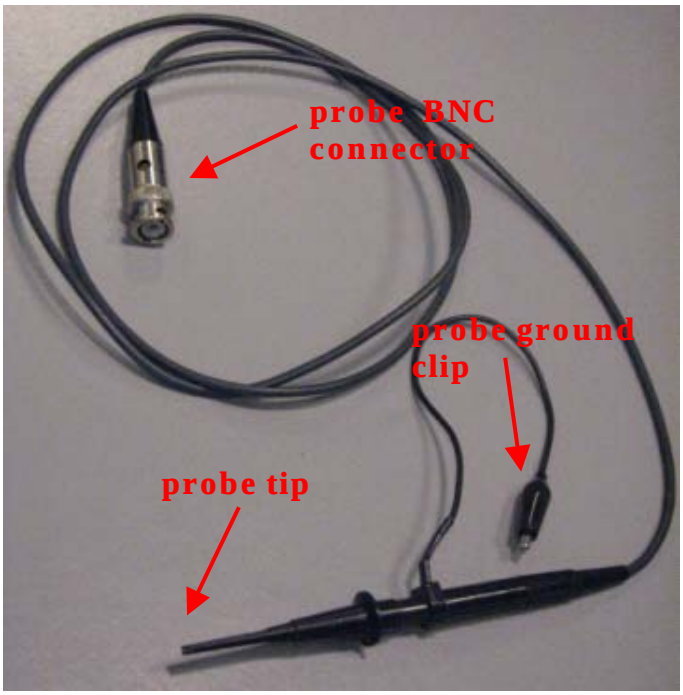


Figure 4.Close-up of an oscilloscope probe (showing the tip, ground clip and BNC connector)

The probe is connected to the oscilloscope using the BNC connector. Then, we measure the potential difference (voltage) between the ground clip and the probe tip.

However, take note that in most oscilloscopes, the ground clip is actually physically connected to ground - which means that it will force a null potential to any conductor it is connected to (that is, it will force it to an uncharged state). So, **be careful where you connect the ground clip**! Usually, for single supply power circuits, the ground clip should be connected to the *negative terminal of the power supply*. (Actually, in these applications, the negative terminal of the power supply is commonly taken to represent the "ground").

So, let us proceed. First we want to make sure that the oscilloscope is giving us a signal we can read.

1. Connect the probe's BNC connector to the oscilloscope channel 1 input:

Figure 5.Connecting the probe's BNC connector, to channel 1 input of the oscilloscope

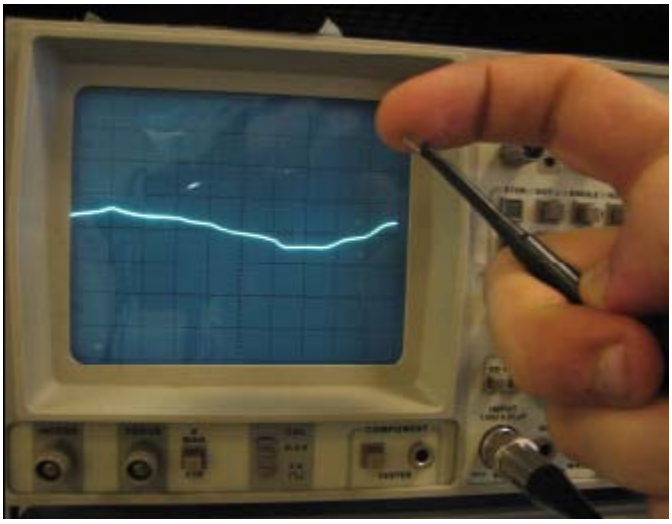
2. Turn on the oscilloscope
3. Observe if you're getting a line displayed on the oscilloscope screen

Note: If at this point you are not getting anything displayed on the oscilloscope, you may want to try the following settings. Take note that a button on the scope if ON if it is pressed, and OFF if it isn't pressed.

- CH I/II, DUAL and ADD buttons should be all off (which sets viewing to channel 1 only)
- Ch.1 GD button should be OFF, and AC/DC button should be ON
- X/Y switch should be off
- Trigger coupling should be on DC
- Intensity and Focus should not be on minimum
- Anything related to snapshot storage should be off
- Hold button should be on OFF possition
- AT/NORM, ALT, +/- and EXT buttons should be off
- Ch.1 Y Mag button should be OFF
- X Mag button should be OFF

4. To make sure that the oscilloscope is responding touch the tip of the probe with your finger, *while having the ground clip floating* (meaning not connected anywhere).

You should be able to get a noisy reading on the scope, depending on your Volts/DIV and Time/DIV settings.



If all is OK, then we can proceed to measuring the power supply voltage. (If not, then there may be problems with trigerring, or other setup of the oscilloscope - so try the above default settings again).

At this point, let us remember that - an oscilloscope measures *potential difference* or voltage, *between two points* - the points where the ground clip and the tip are connected to. On the other hand, remember that in circuits with a single power supply, the ground is taken to be the negative terminal of the battery.

In conclusion, in order to measure the voltage of the power supply, we need to connect: the **ground clip** of the probe to the **negative connector** of the power supply; and the tip of the probe to the positive connector of the power supply.

So, let's try to do that:

5. Connect the ground clip of the probe to the negative terminal of the power supply

6. Connect the tip of the probe to the positive terminal of the power supply

7. Turn the power supply on.

At this time, take note that (in this example) the voltage was determined to be around 11V. On the other hand, the oscilloscope needs to be set to a proper measuring range. This is done through the Volts/DIV switch on the respective channel. So, if Volts/DIV is set to 1V, then it means that the vertical length of a square on the oscilloscope screen grid, is to be interpreted as 1V - as there are 8 divisions in total across the screen, that means that there can be 8V in total shown on the screen - which certainly means that our signal trace will be outside of the visible bounds on the screen.

Note that there is also the **probe attenuation** to take into account as well - probes marked with 10x attenuation, will have such effect, that when say Volts/DIV is set to 0.5V, then the actual meaning of the height of a division will be 10 x 0.5 = 5V.

8. Observe the changes on the oscilloscope.

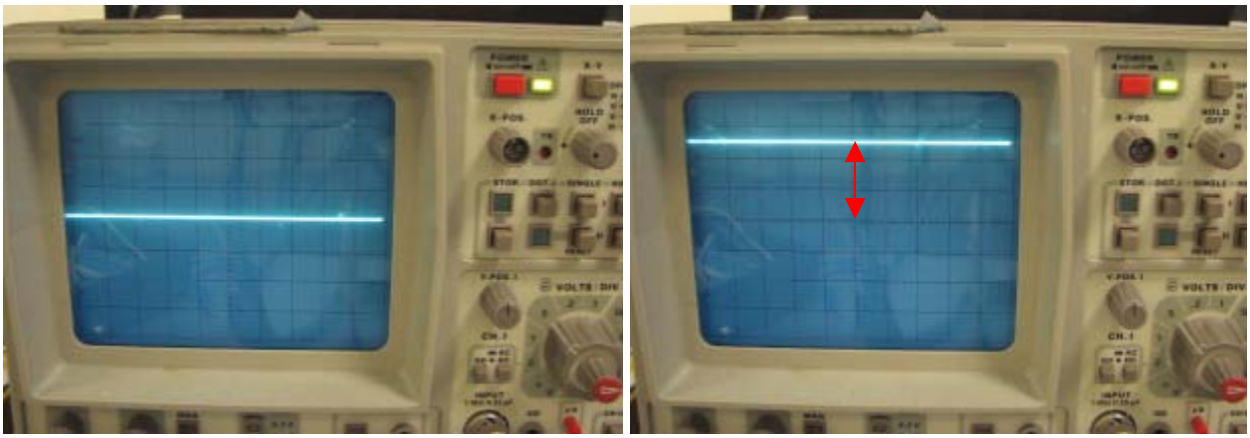


Figure 6. Oscilloscope trace when power supply is turned off (left) and when power supply is turned on (right)

Notice on the figure above, that the situation rendered left shows the trace for when the power supply is turned off. That means that at that time, we should be measuring a voltage of zero - and in addition, the 0V trace is set to be at the middle of the screen.

When the power supply is turned on, the measured voltage is approx. 2 ½ divisions above the line that we declared as our zero voltage (the middle line). As the Volts/Div switch is set to 0.5 volts, we can calculate approximately that the measured voltage should be

2.5 * 0.5 = 1.25 V

However, as we know that the power supply is certainly above 10V, that could mean only one thing - that we are using a probe with 10x attenuation. Knowing this, we can repeat the calculation as

10 * 2.5 * 0.5 = 12.5 V

Which is much closer to the value we expect from our power supply.

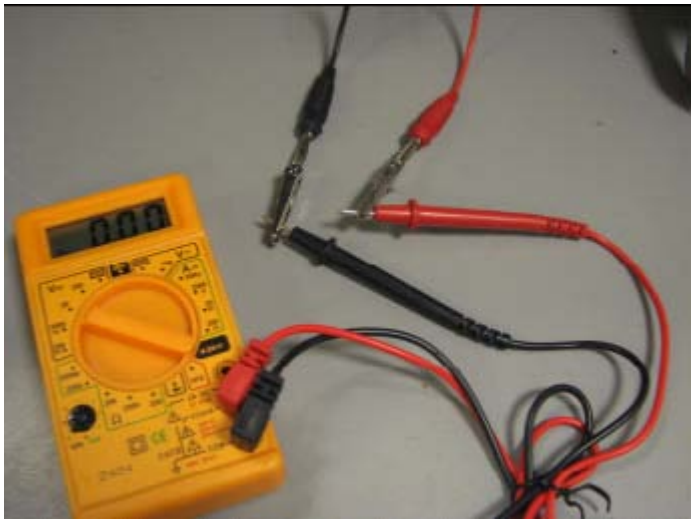
Obviously, is we need a more precise numeric measurement of a given voltage, we could use a multimeter - however, the oscilloscope is important because it helps us visualise the time evolution of a signal.

As an exercise, try to change the Volts knob on the power supply, and observe the changes on the oscilloscope.

2.3 Measuring voltage with a multimeter

Let us repeat the same exercise - measuring the voltage of the power supply; but this time with a digital multimeter. Just as in the case of the oscilloscope, the probes are connected across the voltage we want to measure.

1. Like in the previous example connect the corresponding terminals of the power supply, with the probes of the multimeter. (Negative terminal of power supply goes to common connector [black], positive terminal of power supply goes to volt-ohm-miliamp terminal [red]).



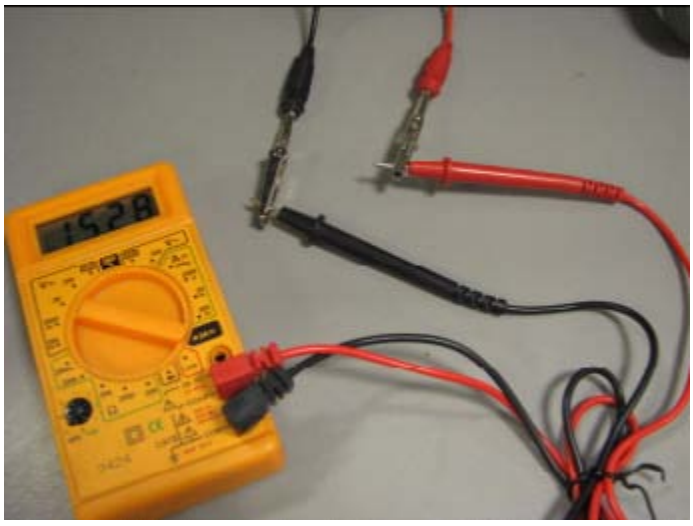
2. Turn the multimeter on, by setting the dial in the proper slot. In this case we want to measure DC voltage, and we do not expect more than 20V (as we know the voltage should be around 11V, had we not changed the power supply).

So, the dial should be set to 20 V DC, as the optimal range to measure our voltage.

If the power supply is not turned on, we should obtain a reading of 0V.

3. Turn the power supply on.

We should now obtain a reading for the voltage. Here we obtain a reading of 15.28 V, which is a bit off than what could be expected. In this particular case, it is most likely so because the multimeter used had low batteries.



2.4 Connecting the soldering iron

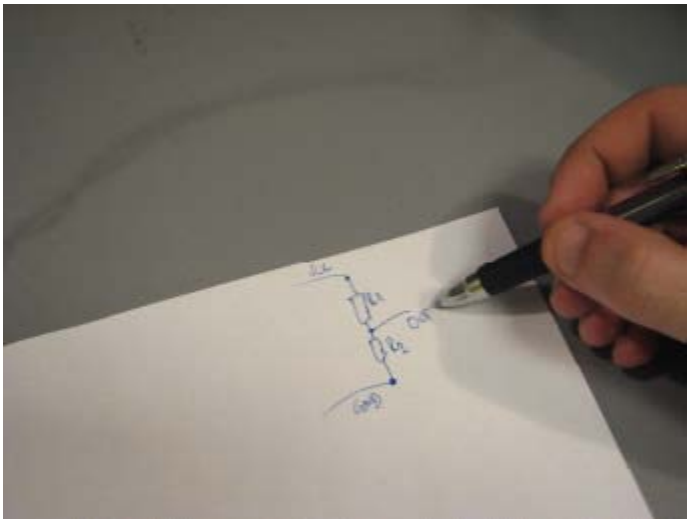
Finally, a few words about the soldering iron which comes with the IHK lab kit. As mentioned previously, it has a special adapter, so it fits only with the soldering iron power supplies, found in IHK labs benches:

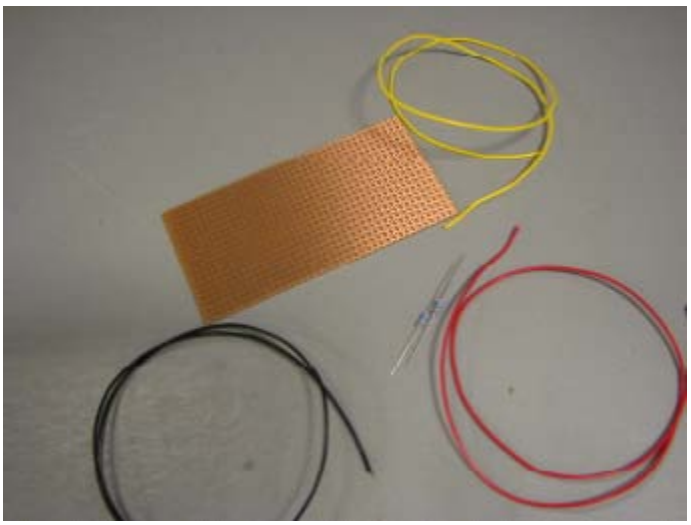
To power the soldering iron, simply stick it in the corresponding socket, (shown on the image on the right)

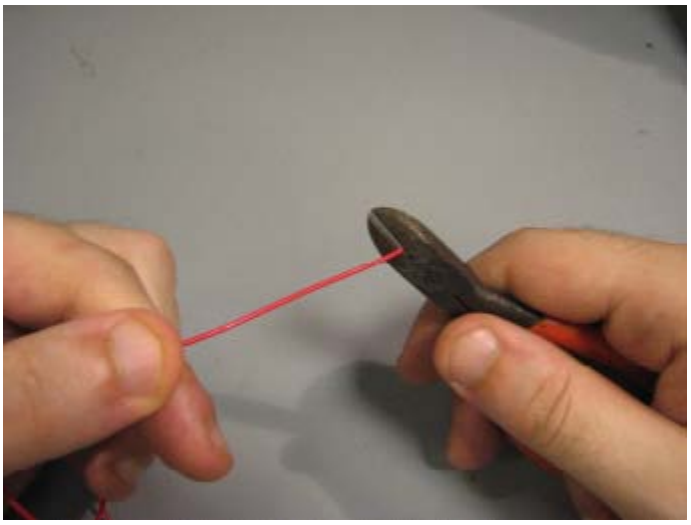
Once connected, the soldering iron should start heating. When done with soldering, just disconnect the iron from the power supply socket.

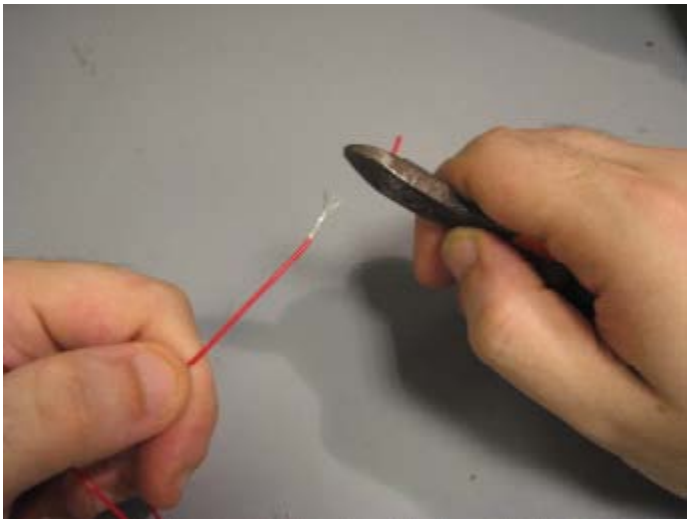
3 A simple voltage divider (with resistors)

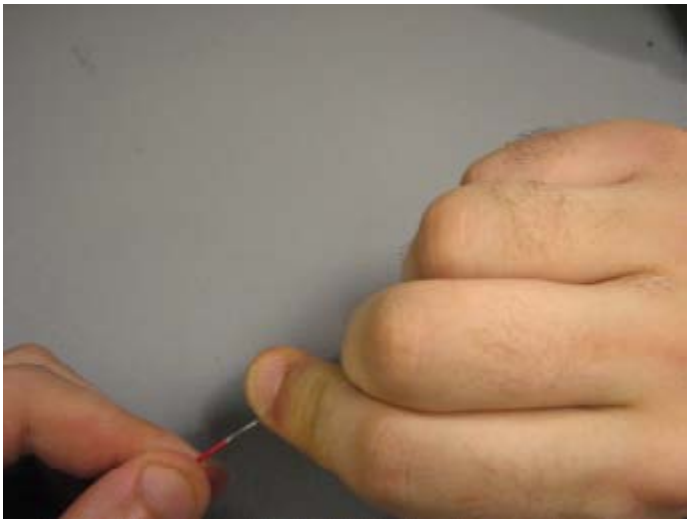
Now we proceed with an implementation of a very simple circuit - a voltage divider made of two resistors. This circuit doesn't do exciting stuff, nor it is very flexible - however, here it will serve as a introduction to practical issues in implementing electric circuits.

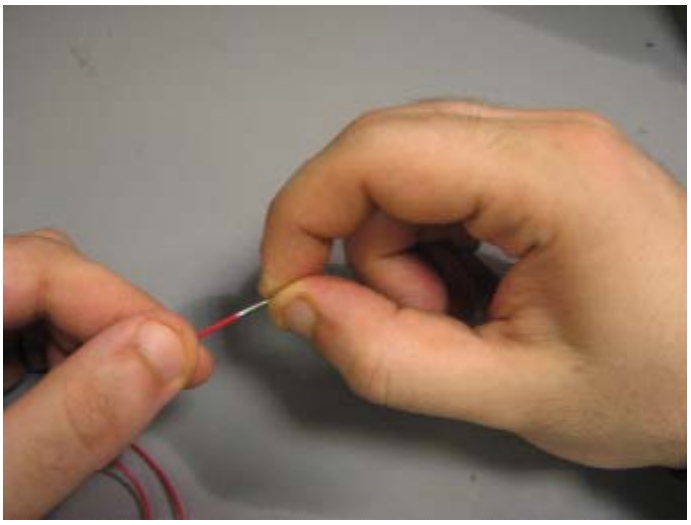


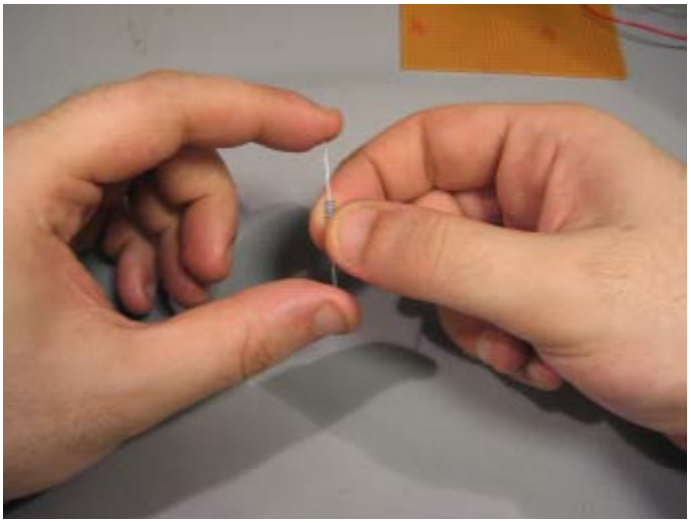


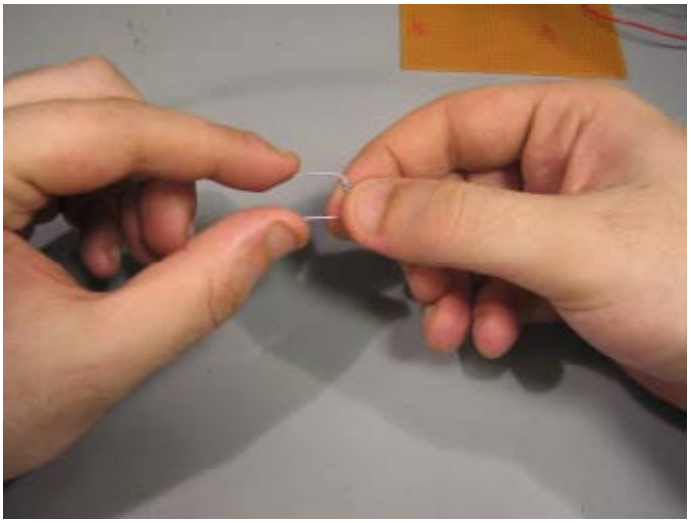


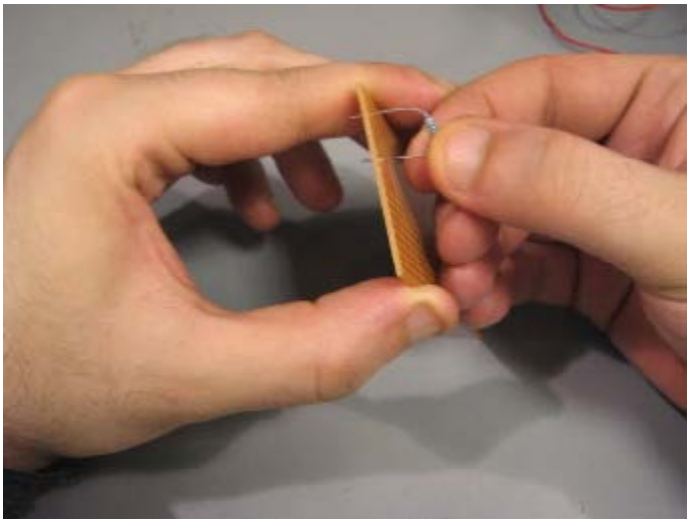


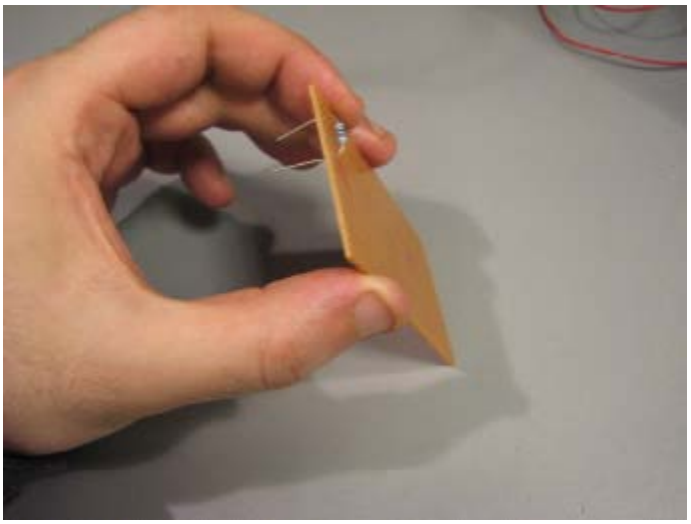


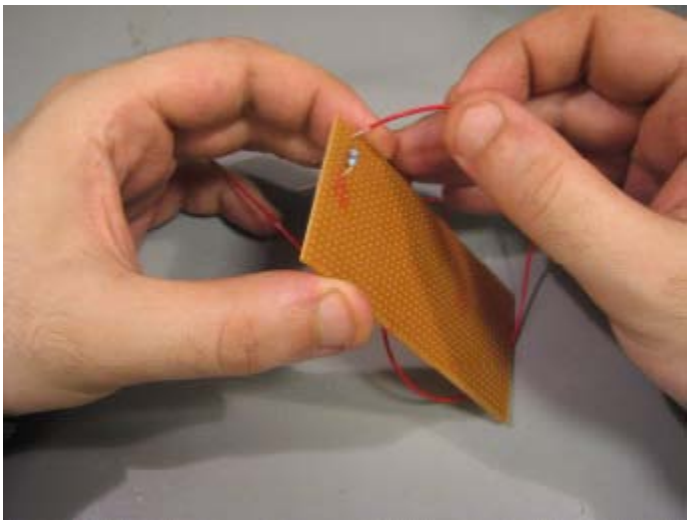


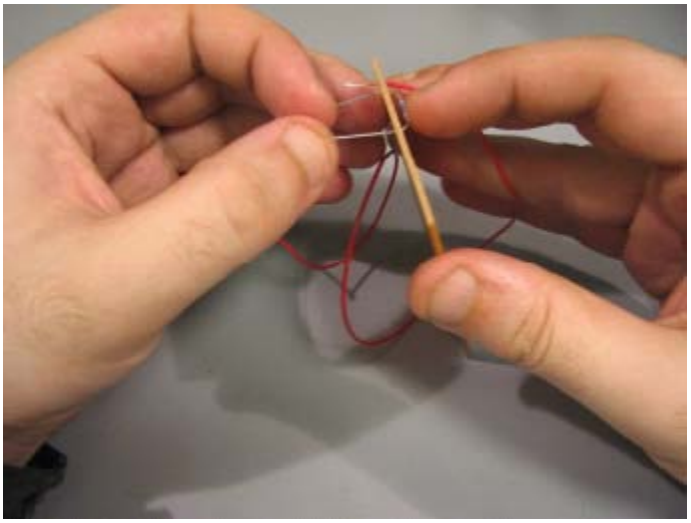


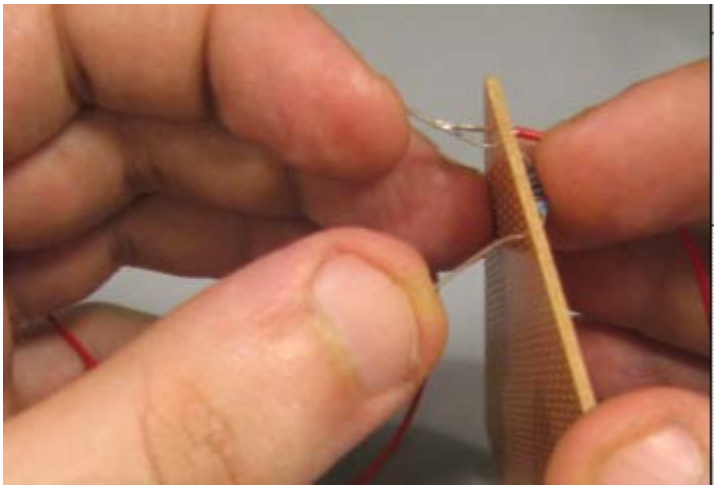


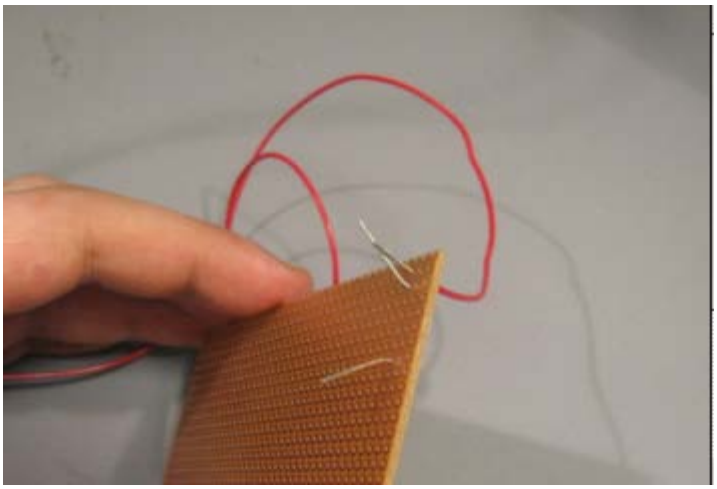


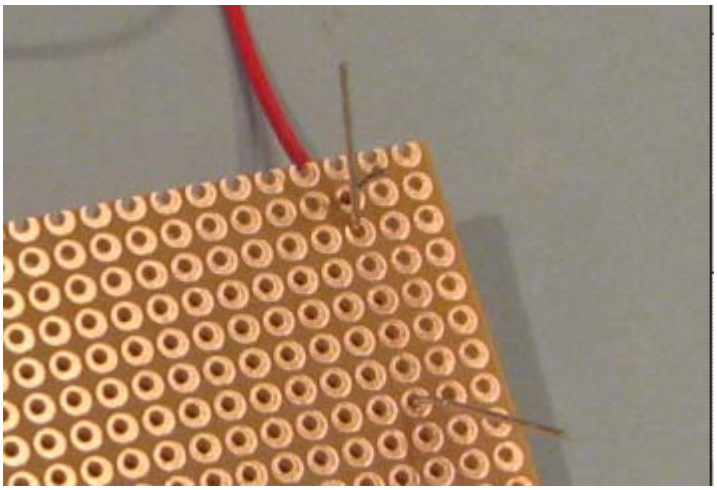


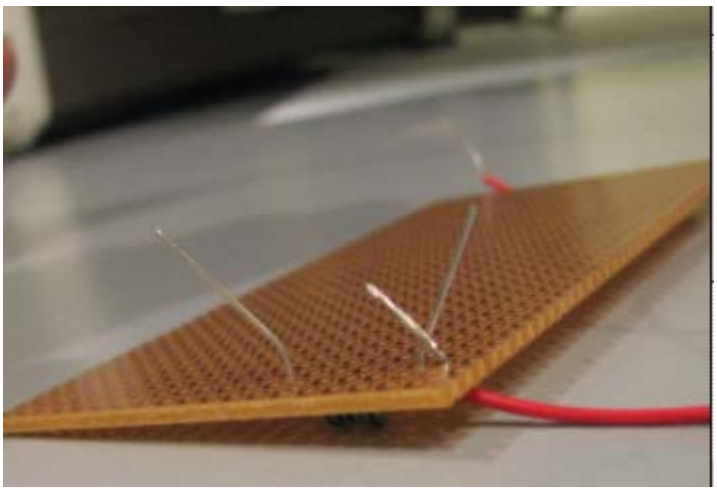


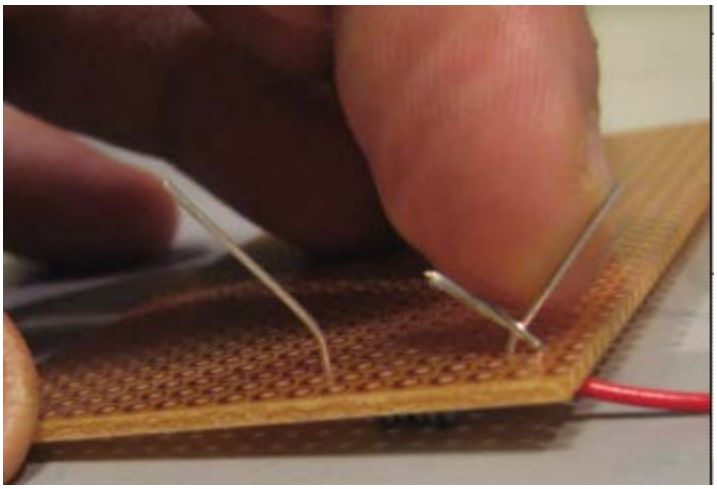


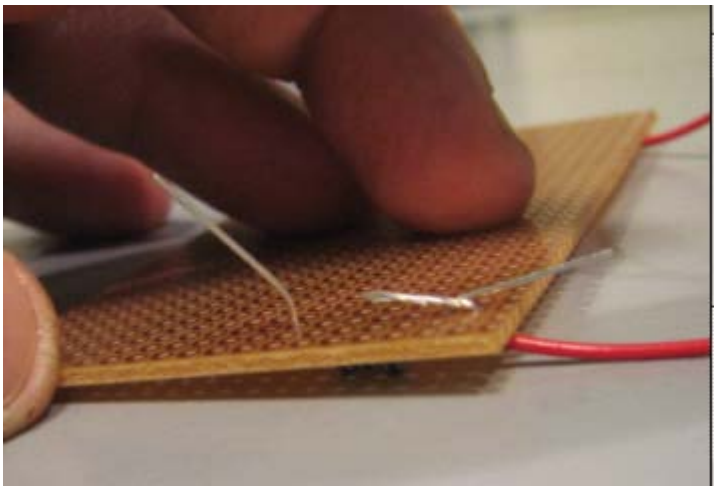


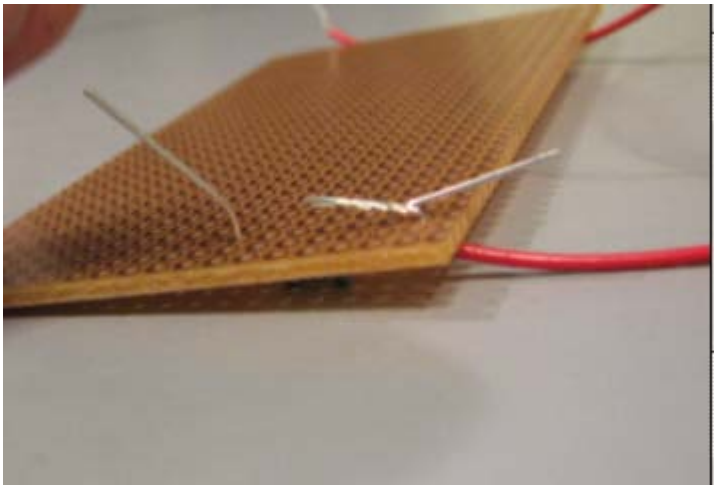


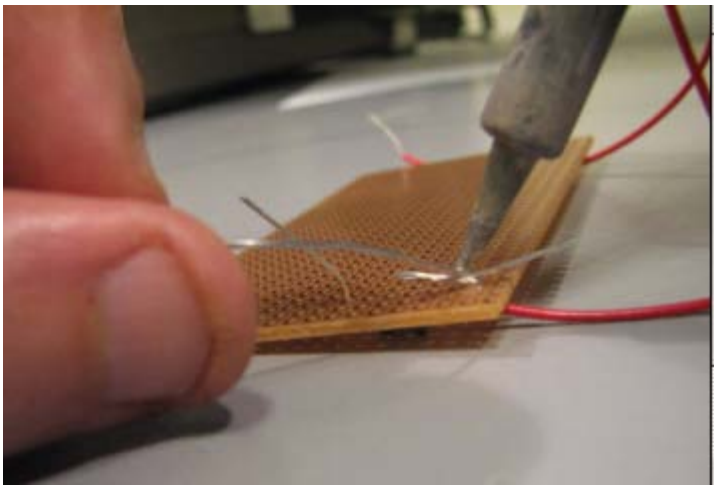


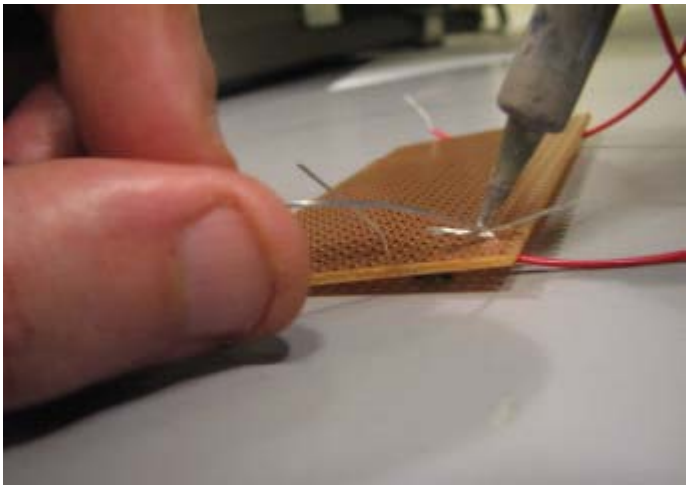


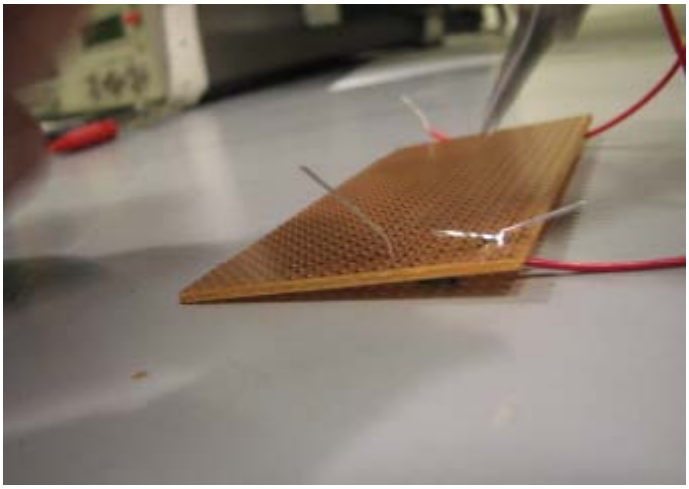


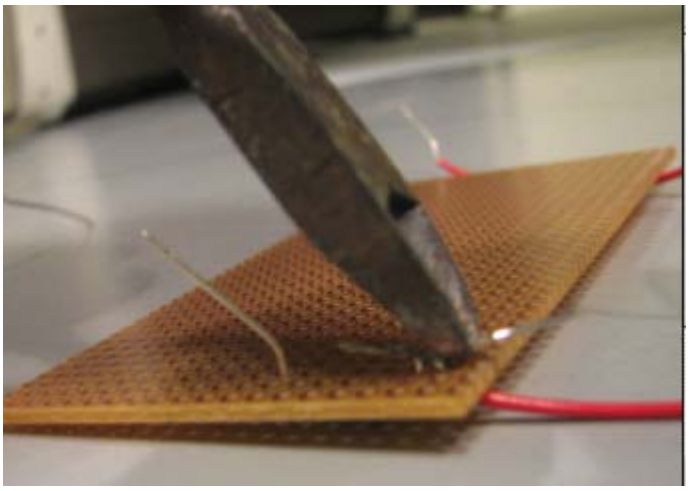


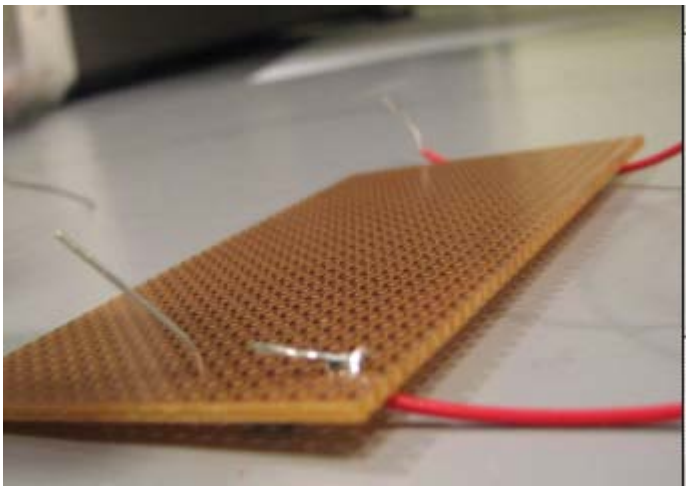


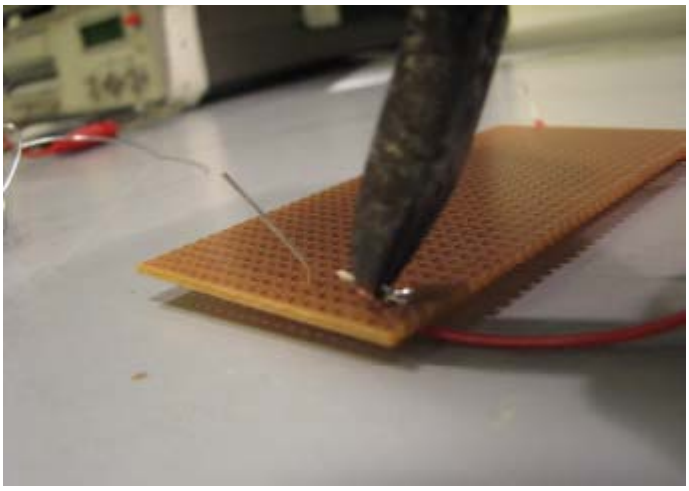


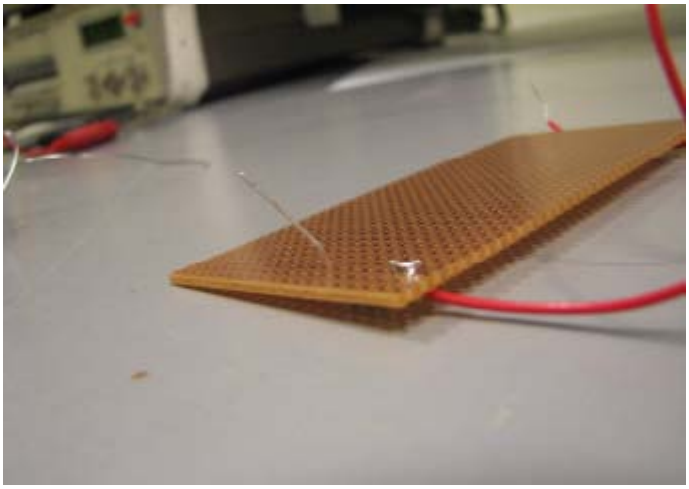


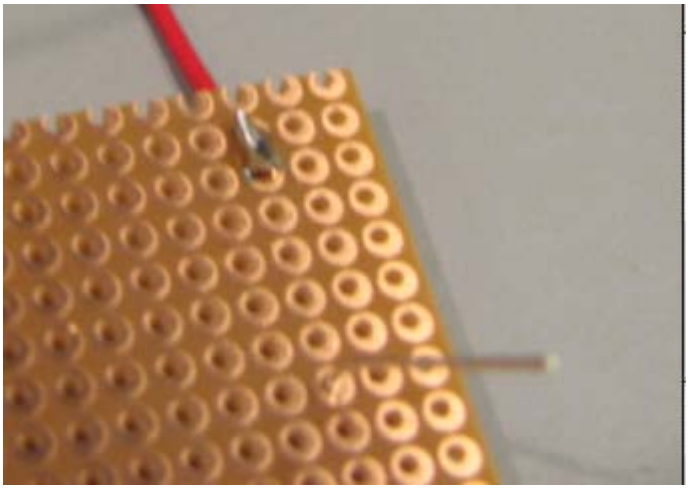


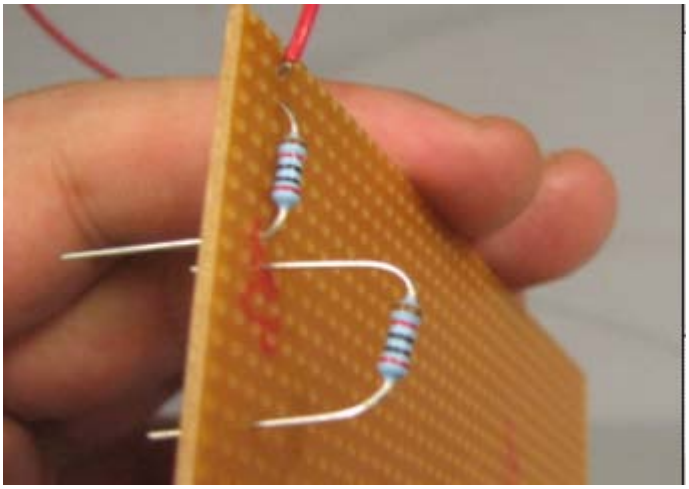


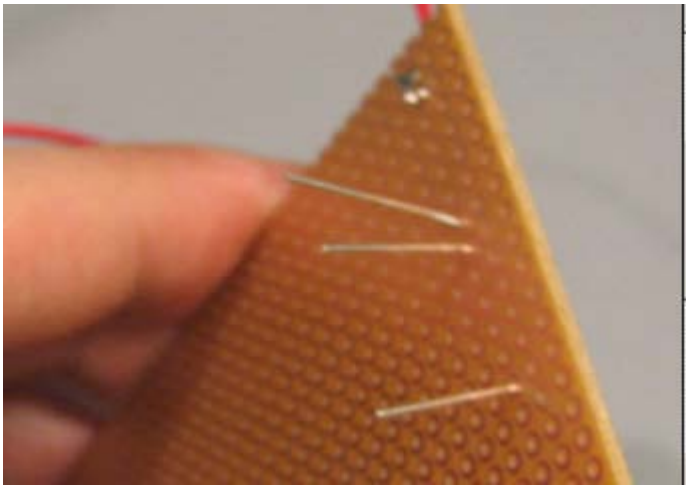


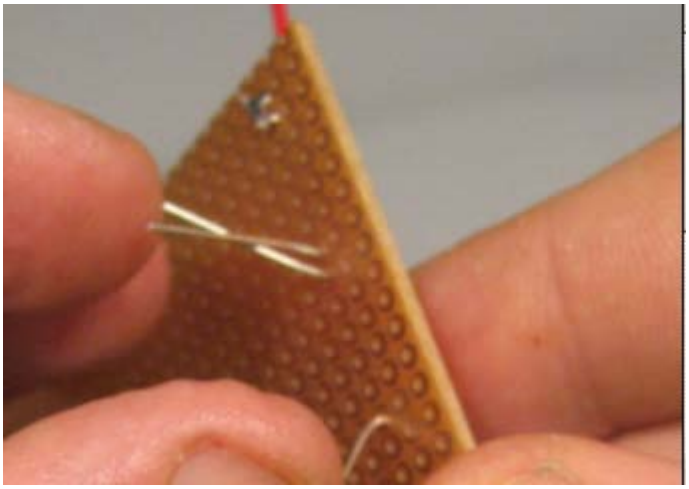


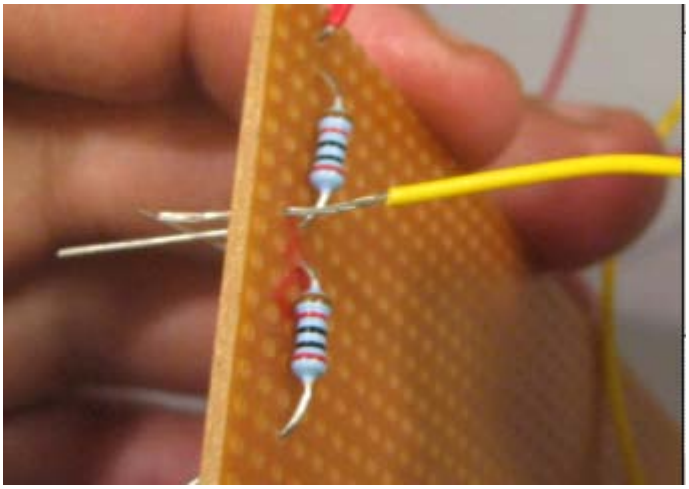


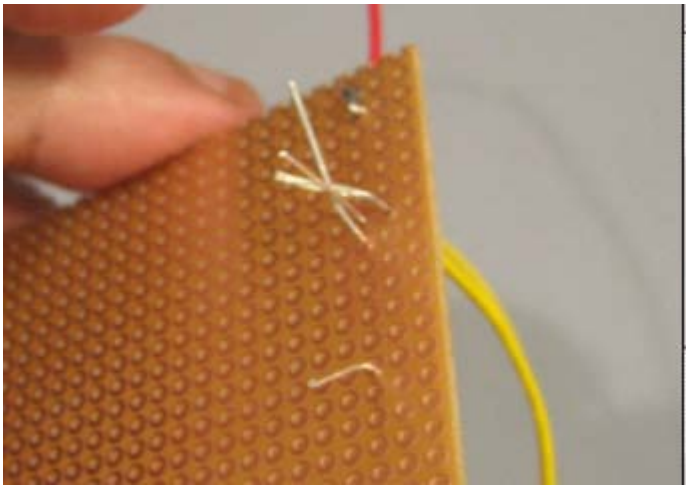


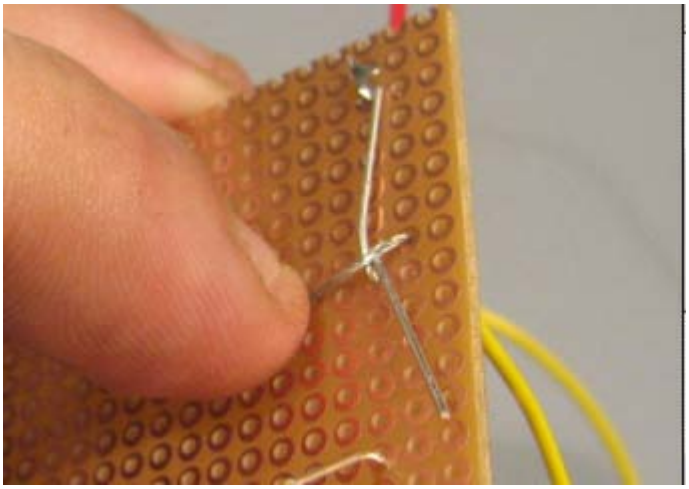


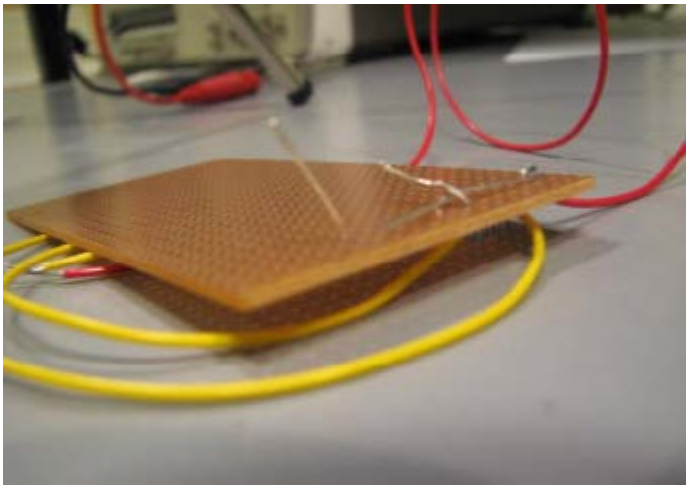


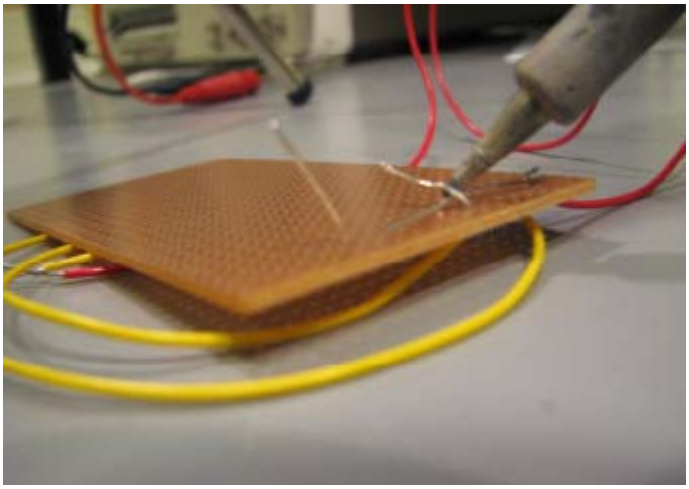


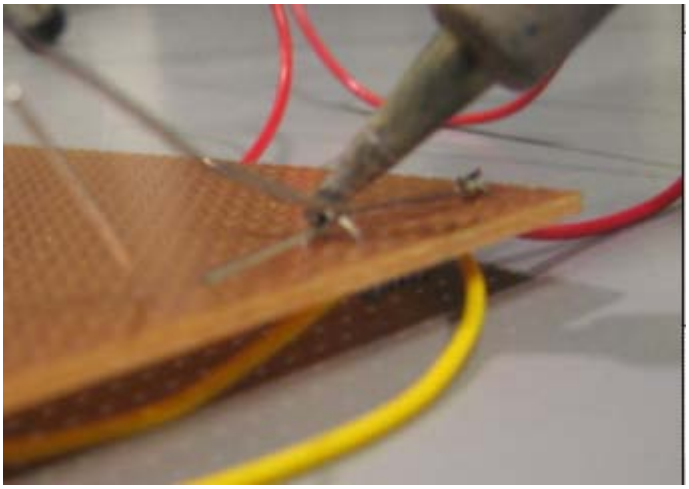


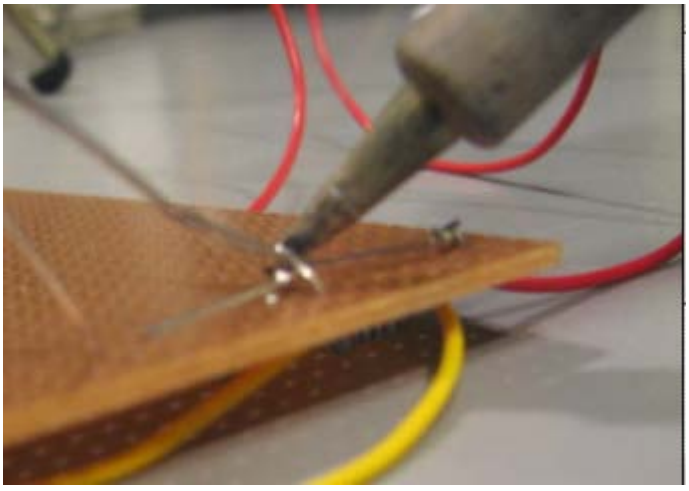


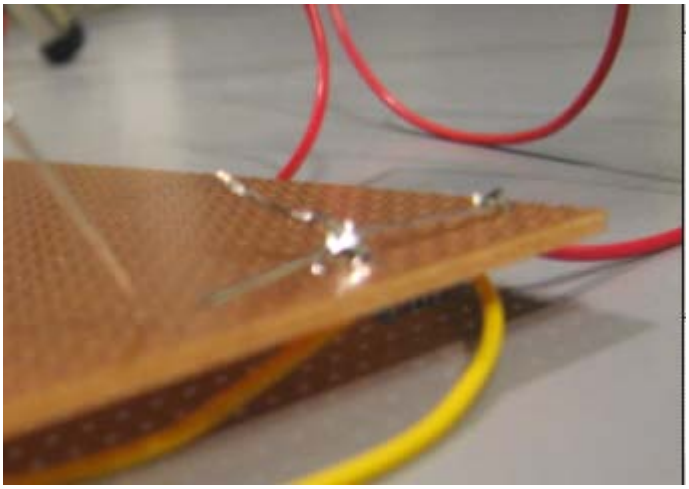


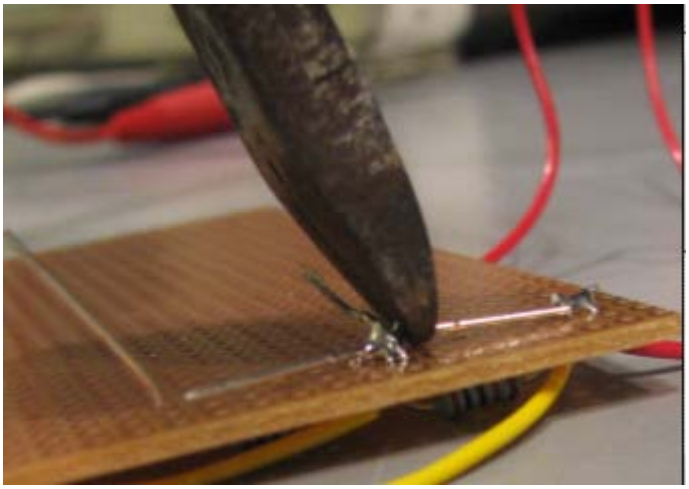


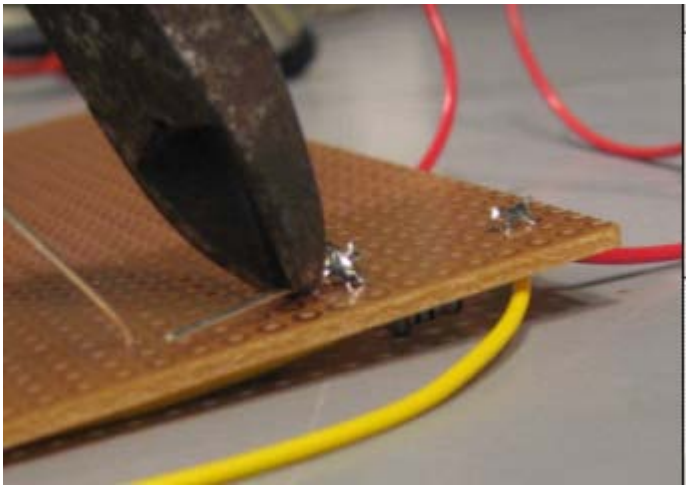


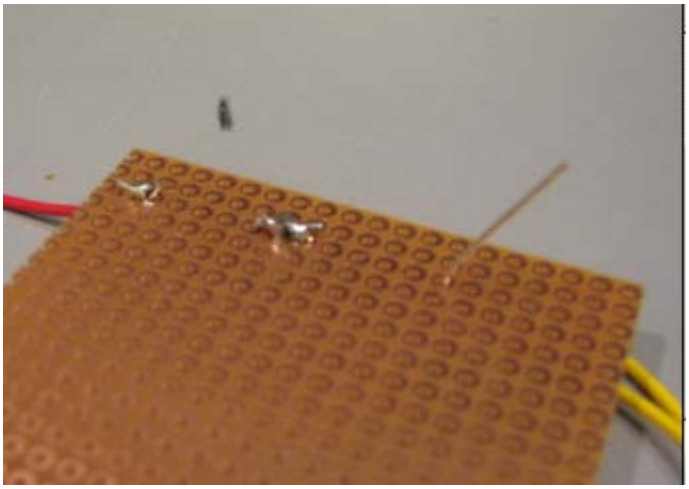


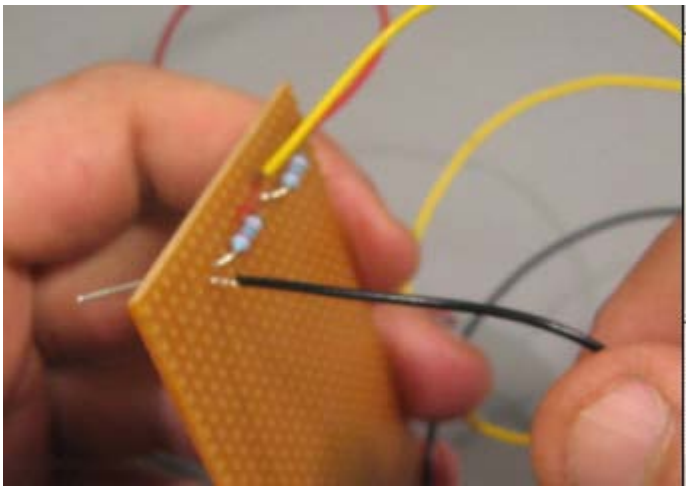


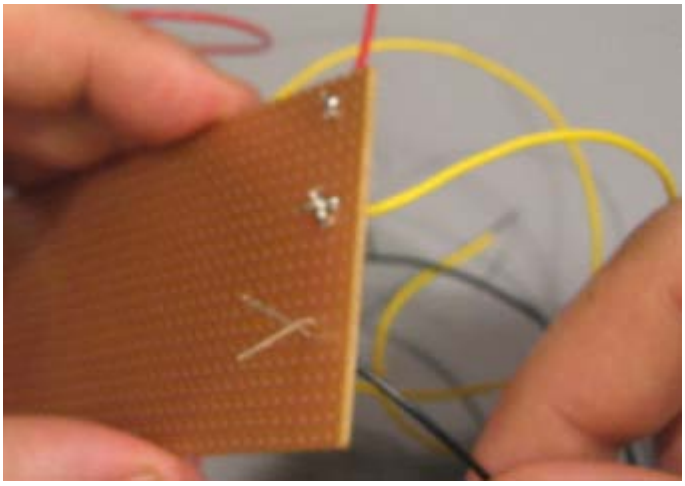


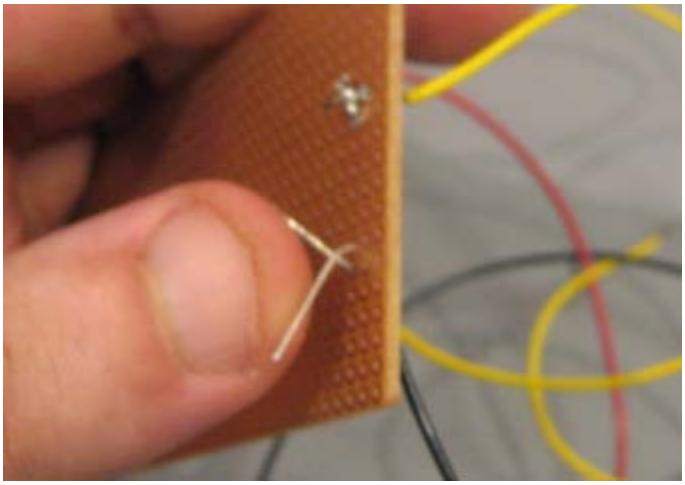


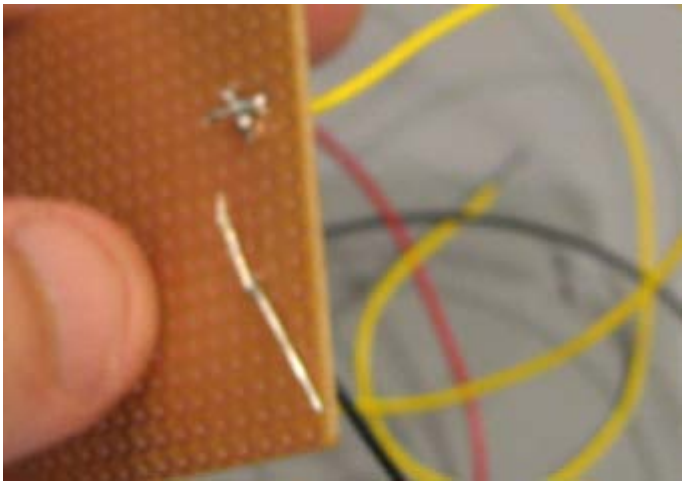


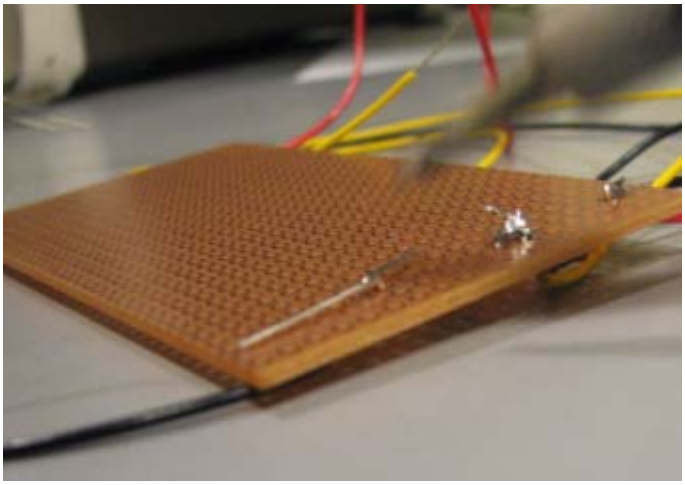


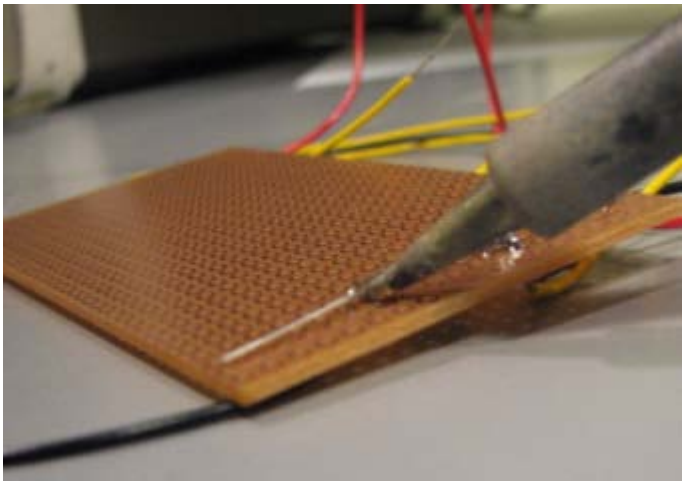


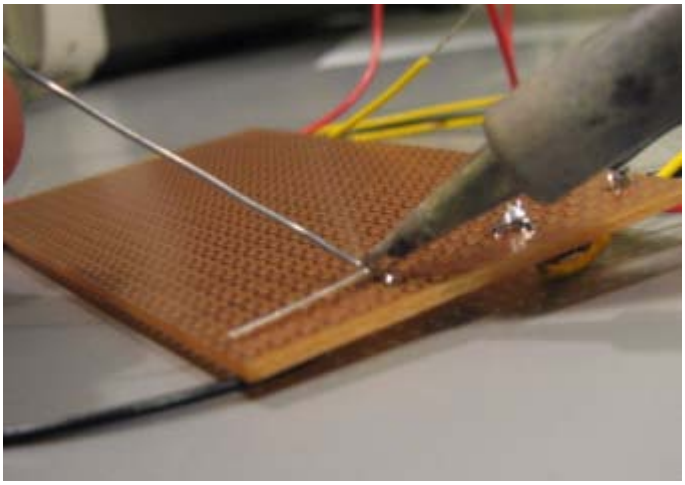


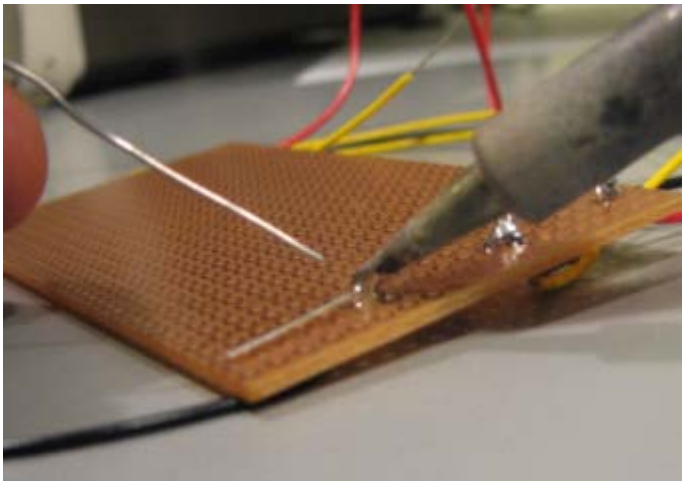


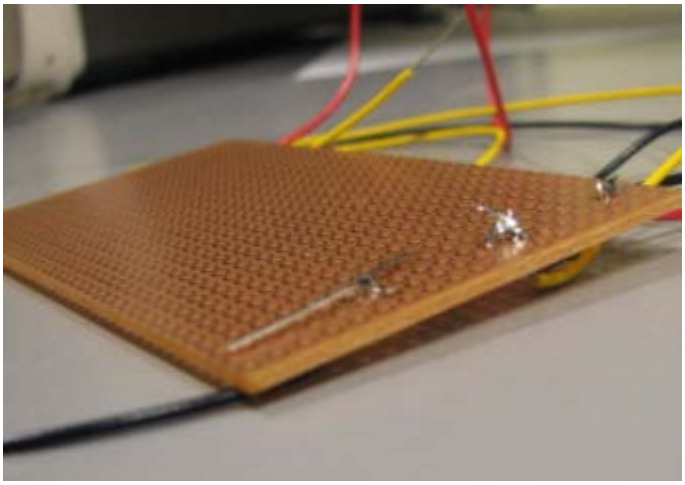


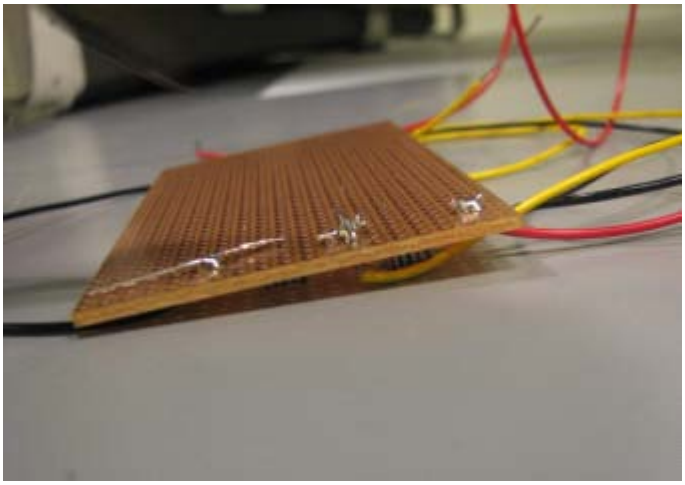


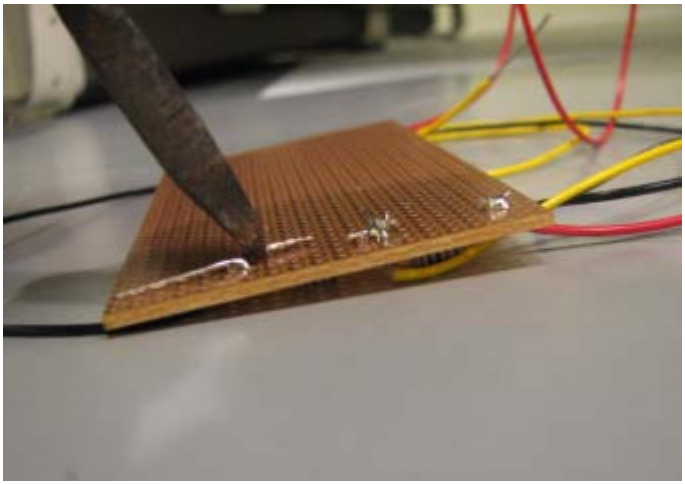


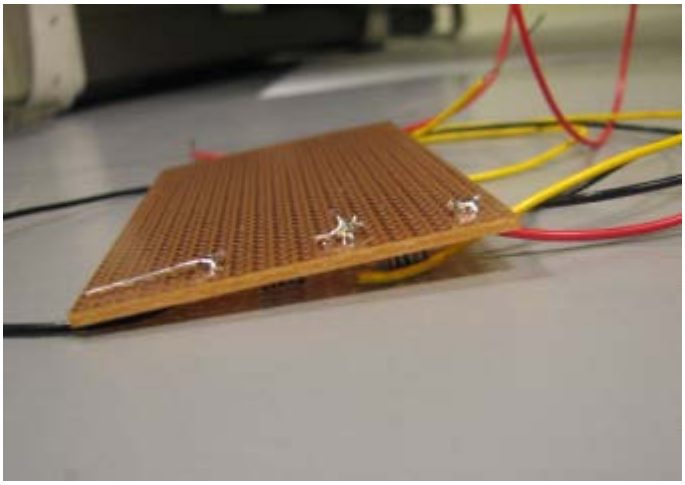


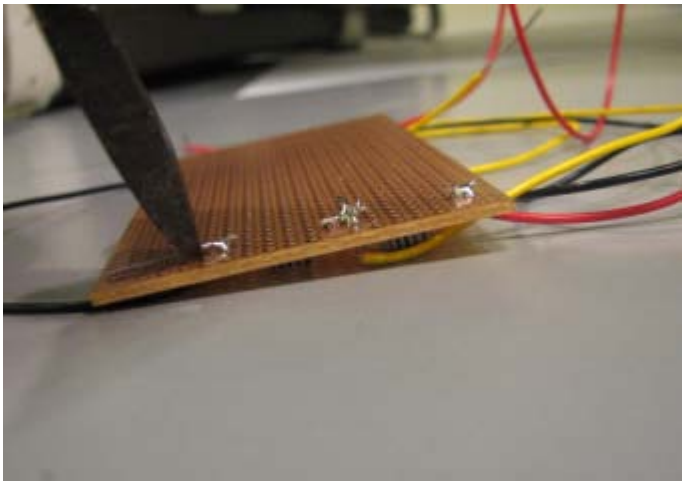


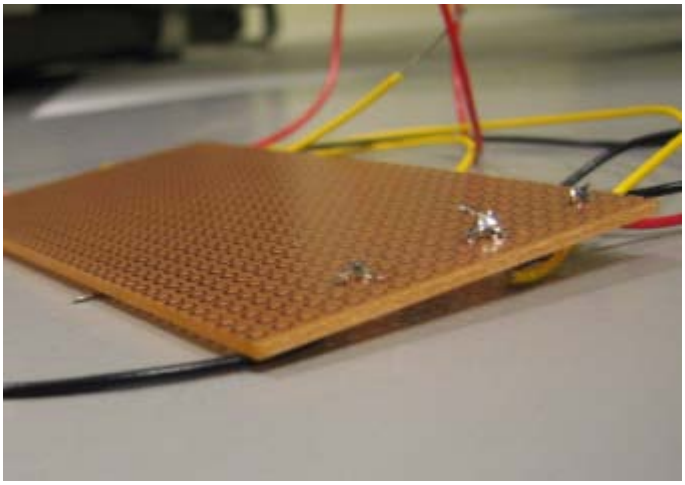


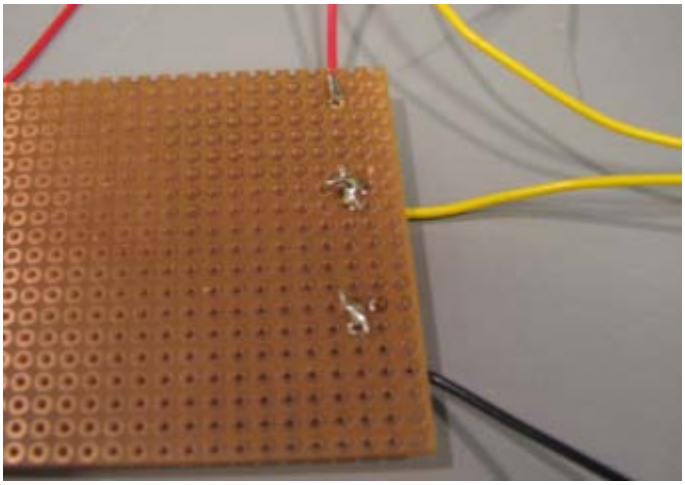


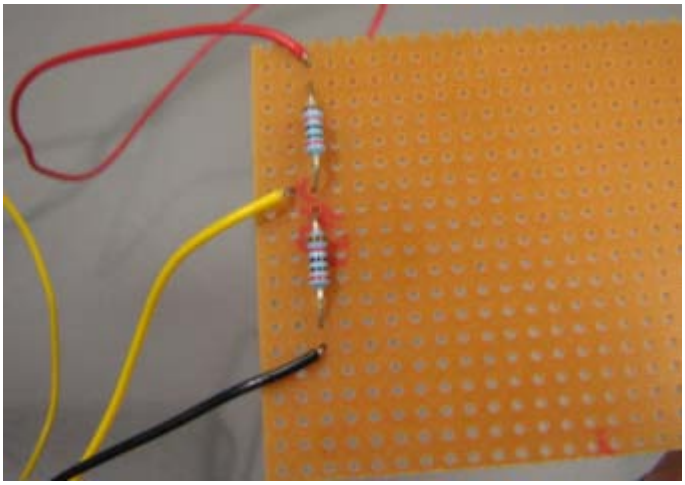


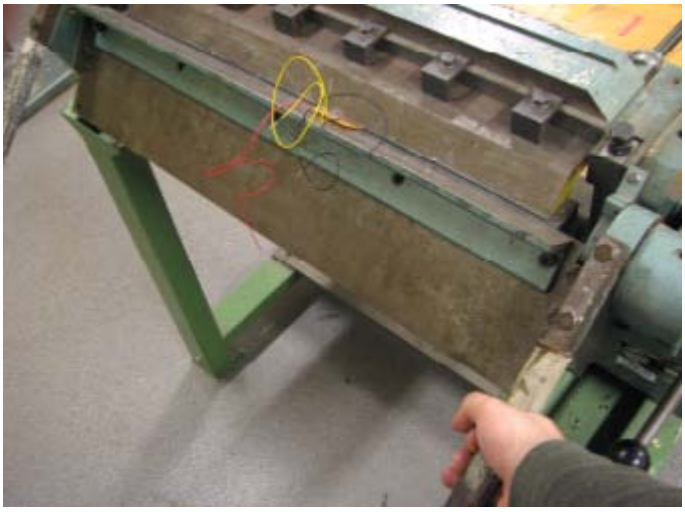


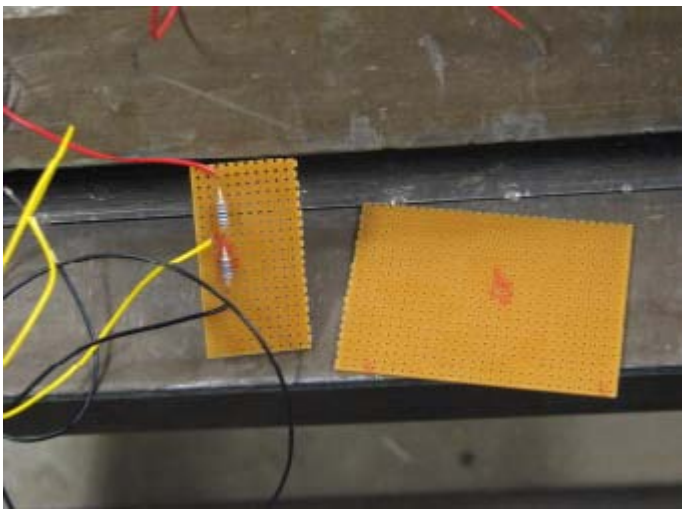




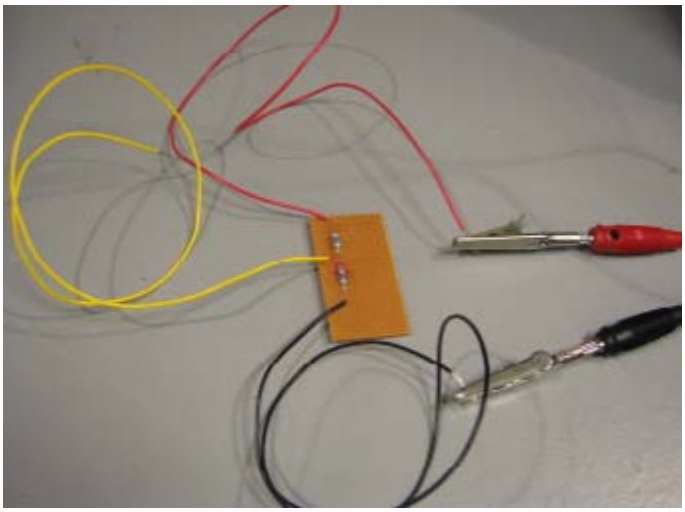


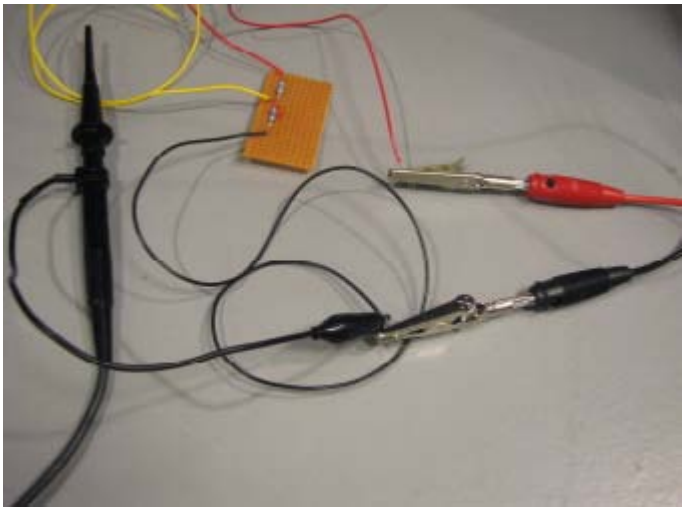


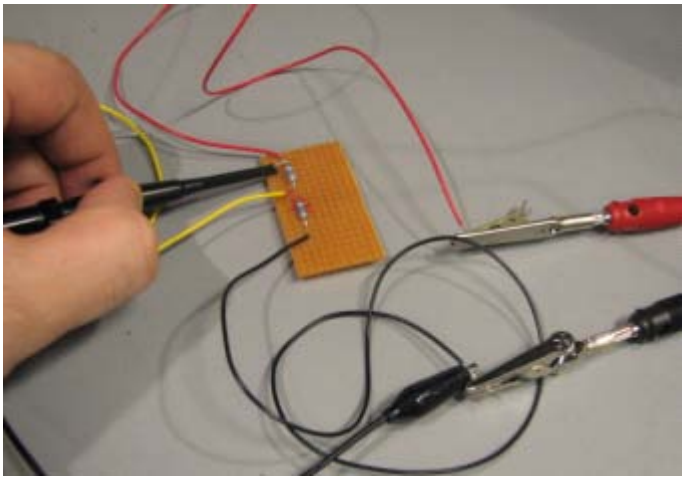


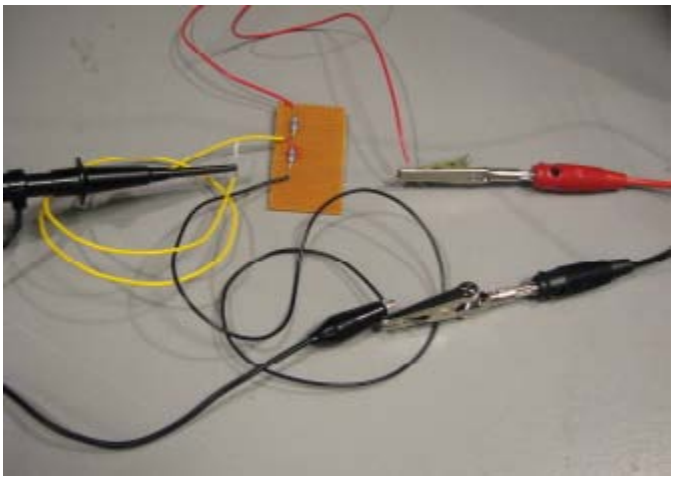


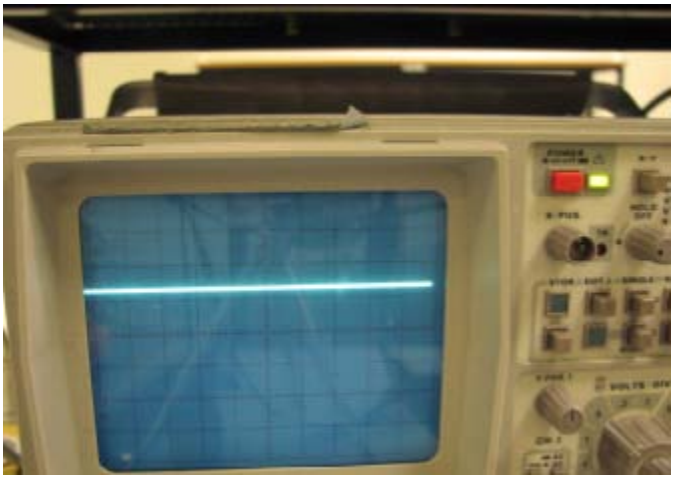
3.1 Powering and measurement

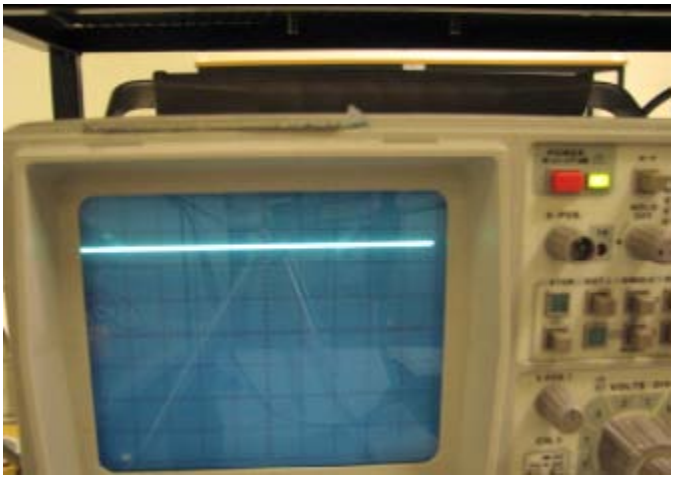




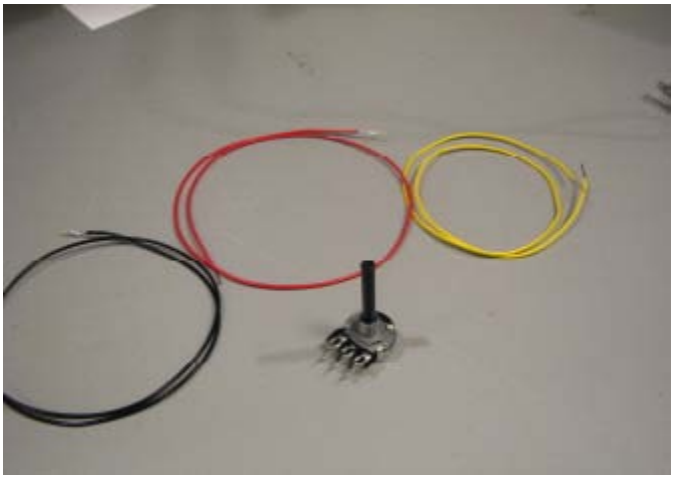


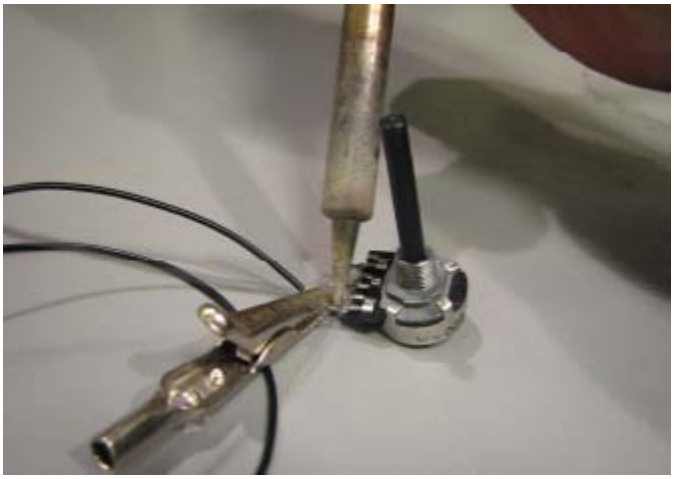


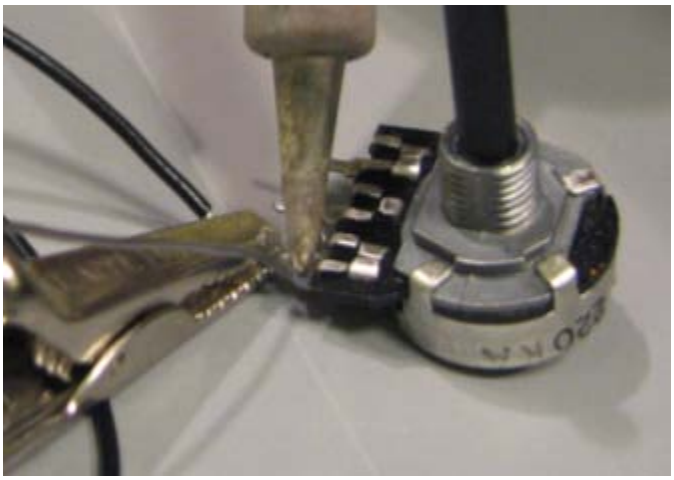


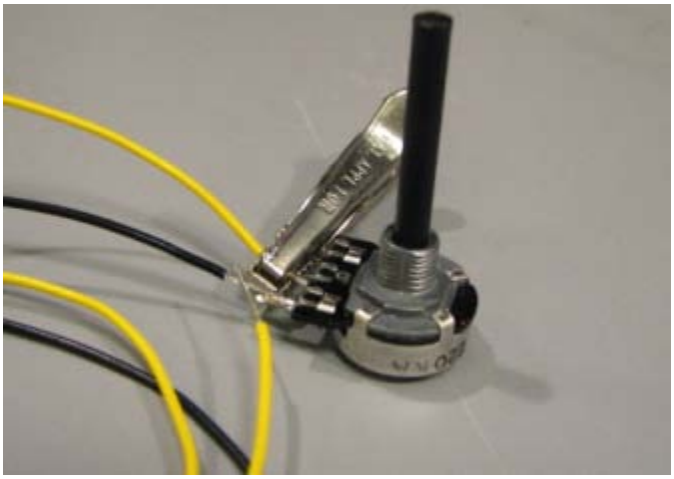


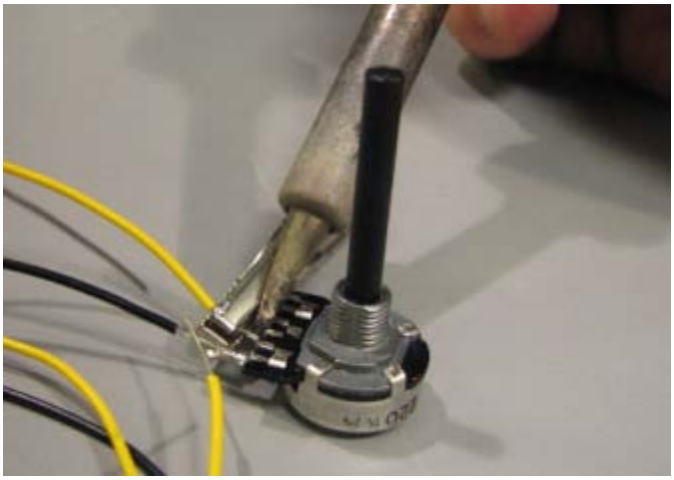
4 Potentiometer

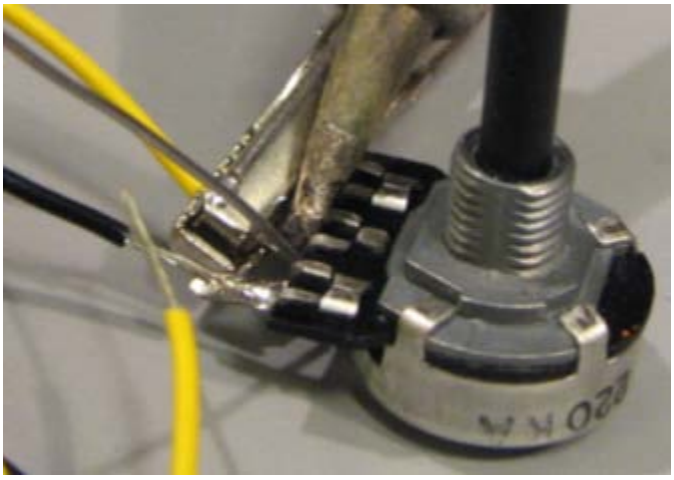


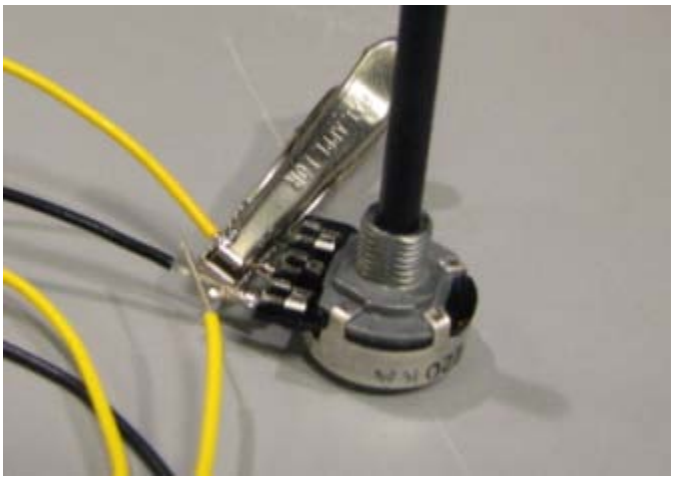


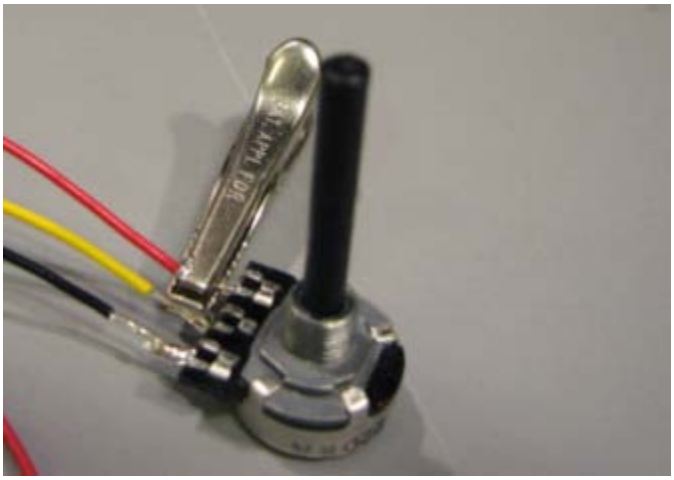


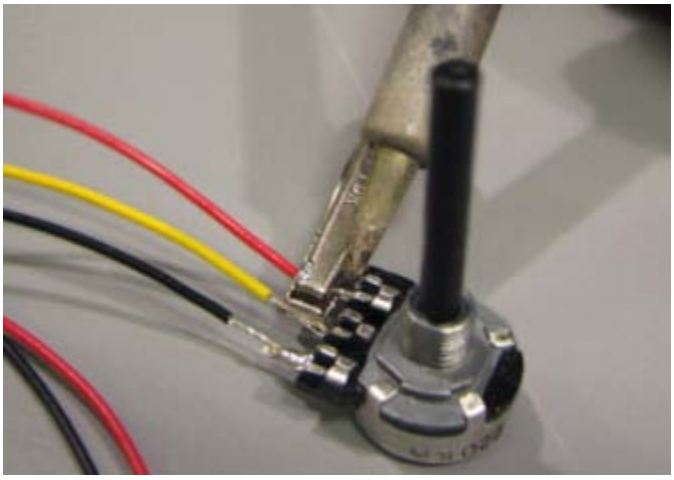


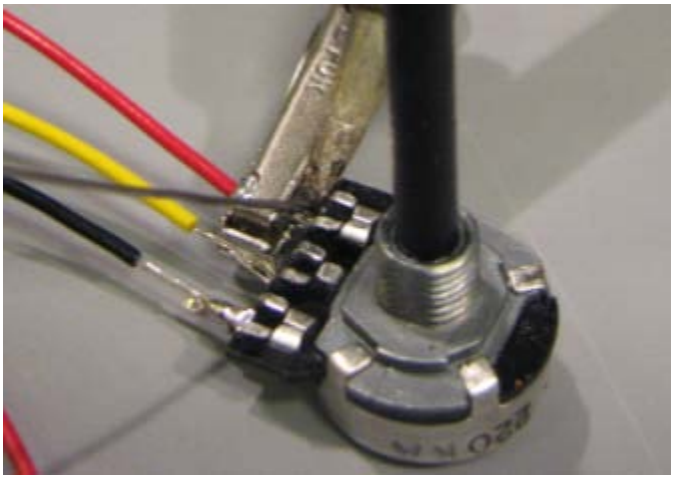


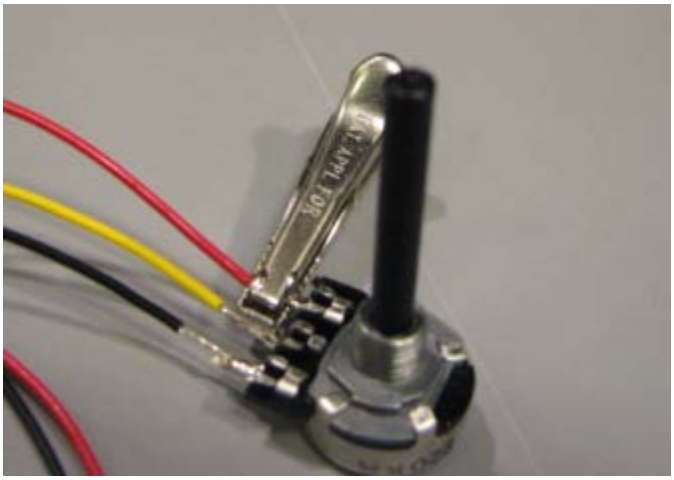


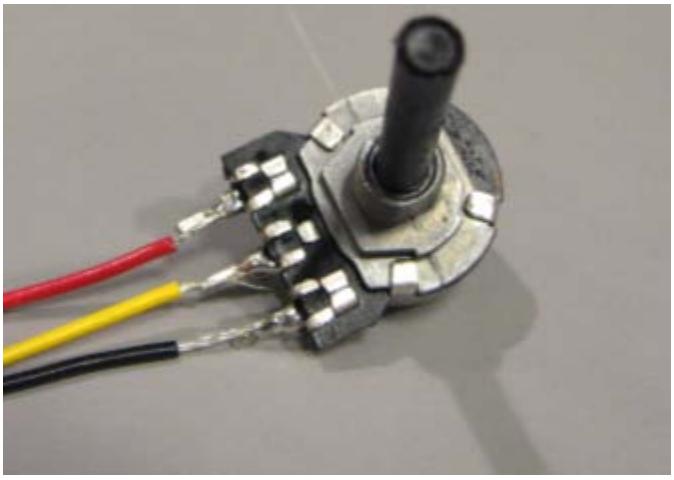




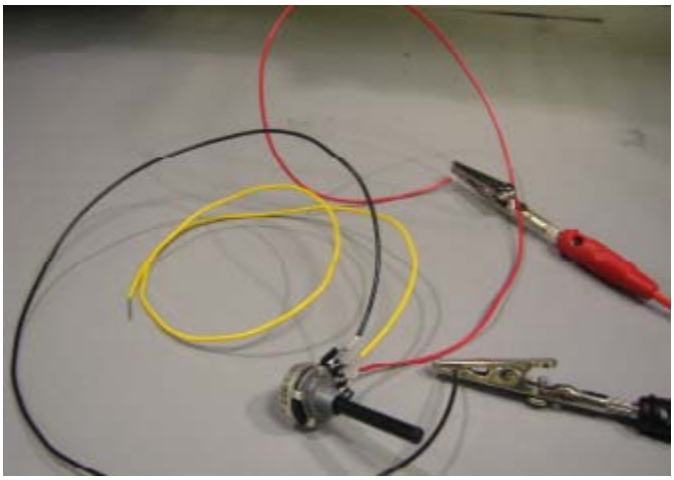


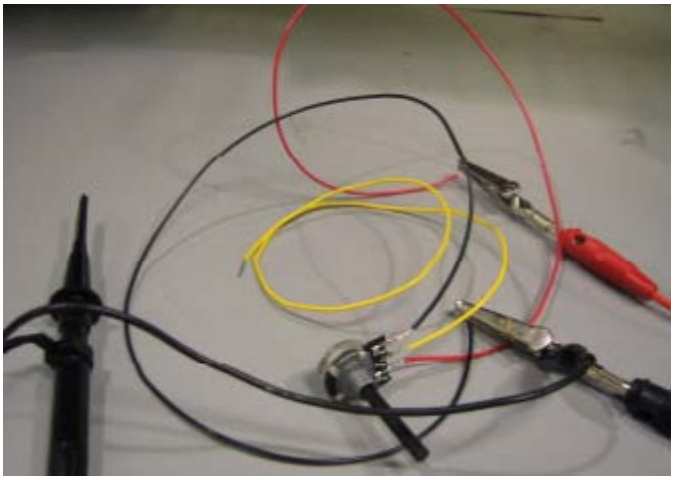


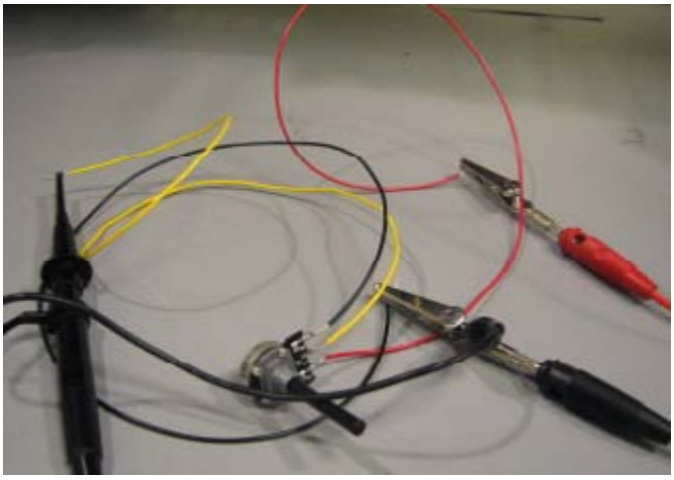


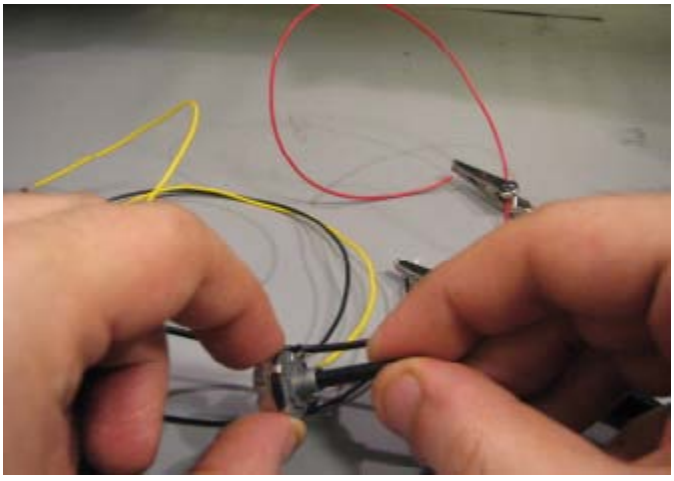


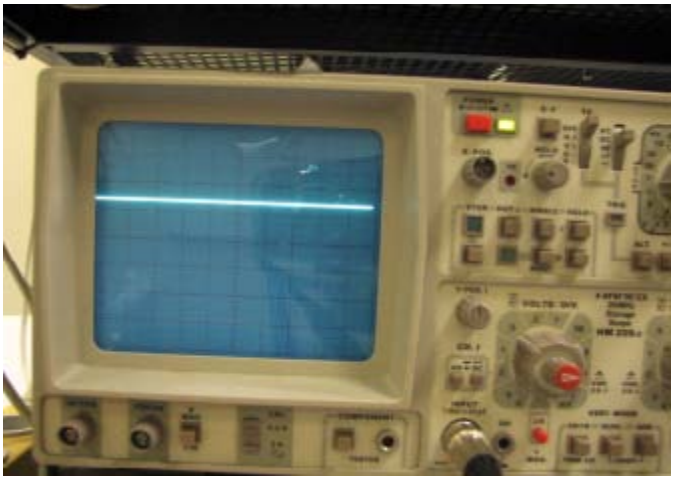
4.1 Powering and measurement

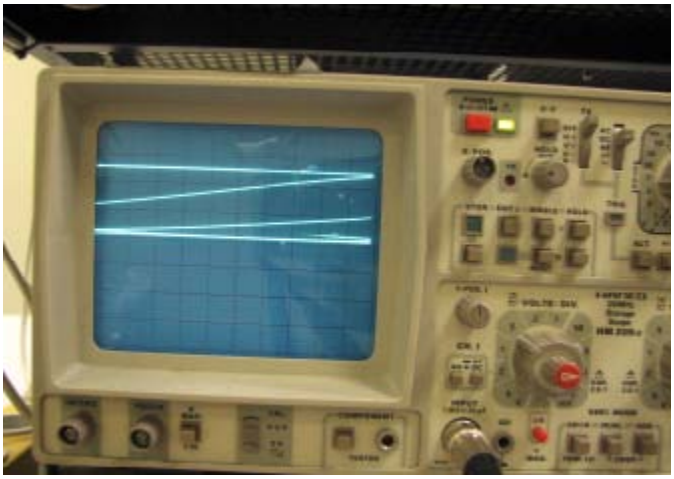












Resources and references

[1]. Peter Debik. “Virtual Oscilloscope: Help ... (oscilloscope simulation / oscilloscope tutorial).” http://www.virtual-oscilloscope.com/help/index.html
[2].