

How to Build Your Own Radiation Detector

Note: This project almost universally is called a Geiger counter, but more strictly speaking it is an ionization chamber. A true Geiger counter is similar, but the tube is filled with a specialized mixture of gases and the exciting voltage is set such that ionizations cascade (multiply), making it much more sensitive.

Materials:

From the kitchen:

Can – soup to paint can sizes are appropriate. Needs to have one end open and the inside must be conductive. Most cans – all that contain food or anything potentially corrosive – have a thin plastic layer on the inside. This can be removed with (a) finger nail polish, (b) emery cloth or very fine sand paper, or (c) heat (acetylene, butane, or propane torch). After removing it, check that the inside surface is conductive with the multimeter (continuity check).

Aluminum foil large enough to cover can opening

Rubberband or string (optional)

Electronics:

A 4.7 k Ω (anything larger than 1 k Ω will probably do) resistor – should be about \$0.04

An NPN Darlington transistor (\$0.27) (part numbers bc517 or nte48 will work). Darlington transistors generally might be hard to find. I will provide you with one for this project, but if you decide to do this for a family home evening project or as a Friday night date, there are several alternatives. You can make one from two normal NPN transistors (rated for about 40 V collector to base and 1 amp current). You may also be able to get this to work with a run-of-the-mill transistor, but it will be less sensitive. NPN (and PNP) transistor schematic diagrams and nomenclature are as follows.

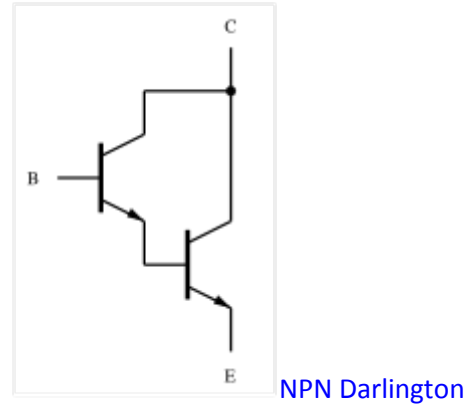
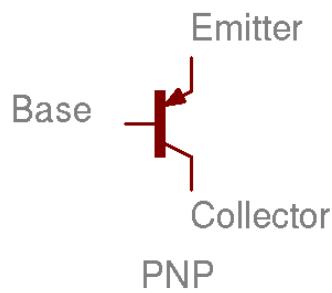
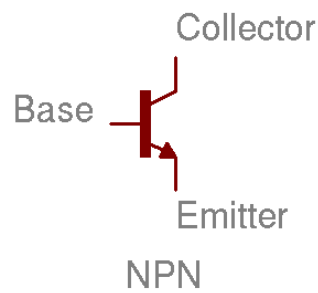


Figure 1 Nomenclature and circuit symbol for NPN and PNP transistors and for a NPN Darlington transistor (right).

To make an equivalent Darlington transistor, connect two NPN transistors as shown on the right above.

A 9V battery cap (optional but quite convenient) (\$0.10).

At least 2x the length of the can in electrical wire (\$0.10).

A 9 V battery (or other suitable power supply).

A multimeter (\$0-\$300). These are frequently offered by Harbor Freight Tools for free but are always available for about \$5 (a very cheap, not especially accurate, analog readout, but sufficient one).

Assembly

Connect the components as illustrated in the following diagram and explained below. Be careful not to run the battery current directly through the transistor without the resistor in line as this will almost certainly ruin the transistor – no transistor can tolerate that much current.

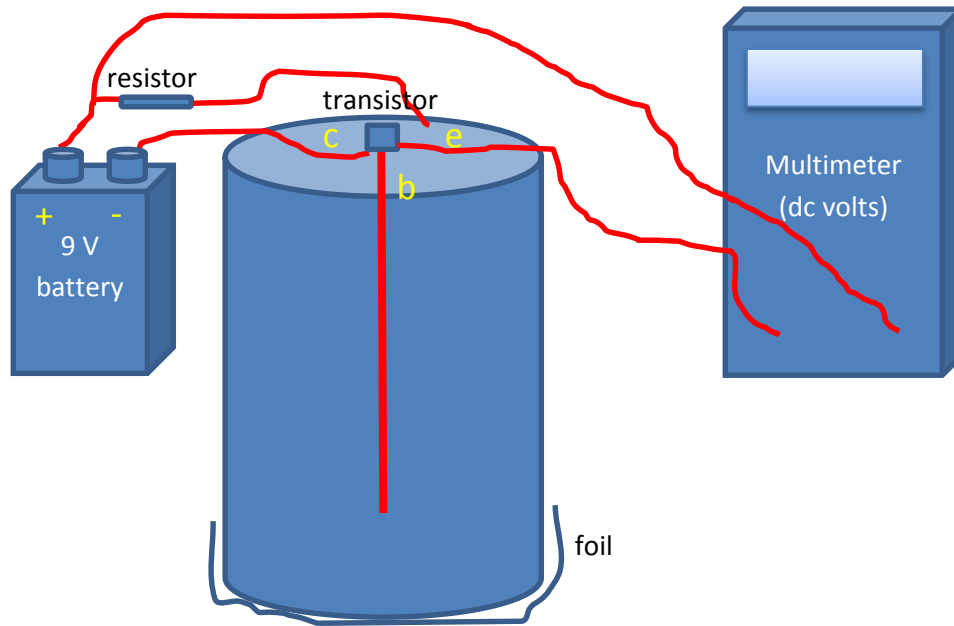


Figure 2 Diagram of a simple ionization chamber.

1. Make a small hole in the center of the closed end of the can. Connect a stripped wire to the base terminal of the transistor and insert it through the hole, being careful that the wire does not contact the can. Bend the other transmitter connections so they do not touch the can and mount the transmitter on the can. Optionally (not very important) seal the small hole with some insulating material.
2. Connect the collector terminal of the transmitter to the negative terminal of a 9 V battery. Connect the positive terminal to the resistor and the resistor to any external portion of the can in electrical contact with the rest of can. Also connect the positive end of the battery to the multimeter. Connect the other terminal of the multimeter to the emitter end of the transistor. The multimeter should be turned to dc voltage and set at a small range.
3. Place the foil over the open end of the can.
4. Connect the 9V battery (or, if you want to increase response and sensitivity, 2 9V batteries in series) to the circuit.

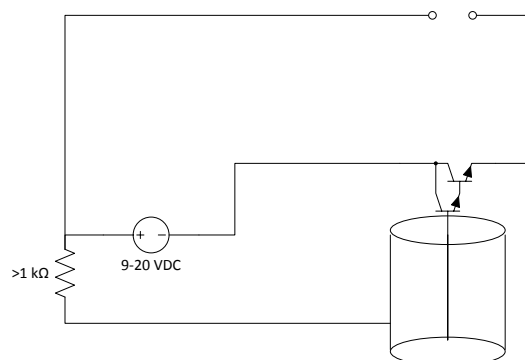


Figure 3 Equivalent circuit diagram for the ionization chamber

Experimentation

Allow the circuit to equilibrate (should come to a small number of millivolts) based on background radiation and RF interference. It will be very sensitive to touching it and even moving around it, so do this in a room without a lot of traffic. It will probably respond to the lights being on or off, depending on what type of lights you have, but this response is probably dominated by radio-frequency (RF) noise, not radiation.

After it has equilibrated, place a radiation source (radioactive sample, Fiesta ware, old glowing clock faces/dials, potassium-based salt, bananas, sources from old smoke alarms, etc.) either under the aluminum foil or inside the can and reseal the system and let it equilibrate again. Gamma radiation (most of the sources above) will easily penetrate the foil and be detected. Beta radiation will be somewhat attenuated by the foil. Alpha radiation will be completely blocked by the foil and must be placed in the can to be detected.

Safety Issues

All of the electrical connections can be done with alligator clips (available for \$0.30/ea. in the electrical engineering supply room, 418 CB). It is a little less awkward to solder most of them. If you choose to solder them, please observe the following safety protocols:

1. Do not inhale the solder fumes. Modern solder is lead free but still not healthy to breathe, so be sure you work with your hands and work in front of you so the fumes can waft away without you breathing them. Do not work over the top of your work.
2. Respect the heat of the gun/iron, and mind where you put it. Solder guns/irons can cause nasty burns and, if carelessly handled, fires. Make sure you work at a clean area and have a safe and secure place to set the gun/iron.

Also, note that solder will not adhere well to cold wires. When you solder electrical wires (or, for that matter, anything else), the parts being soldered must be hot for good adhesion. The best technique is usually to place the gun/iron on the wires or part being soldered to heat it up, and then place the solder on the part. Do not place the solder on the iron and drip hot solder on cold parts. In this case, the can in particular will be difficult to solder unless you let the iron warm it for a several seconds before applying the wire and solder.