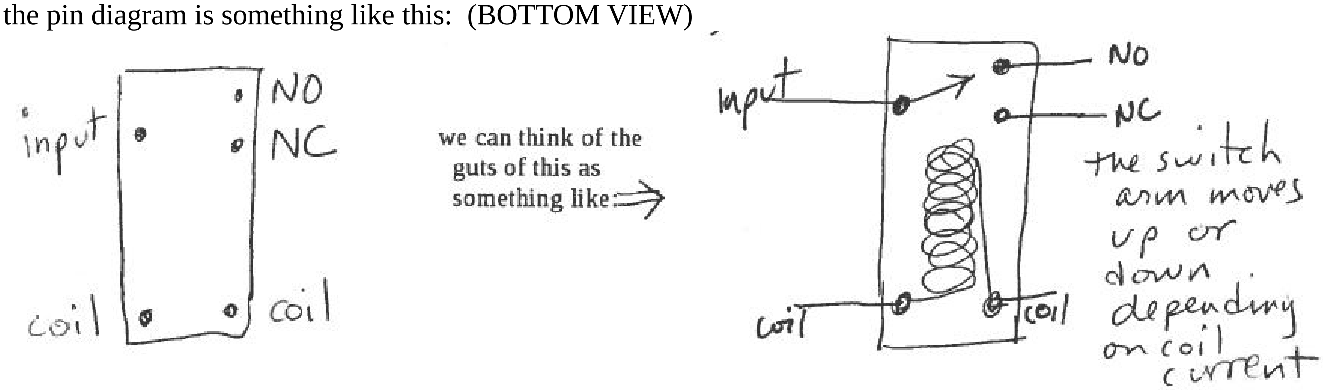
More Power – Transistors, Relays, etc

Make sure you can do the buzzer with transistor exercise described previously.

Transistors can source a lot of current. Often we are using them just as a switch, though, to "turn on" something. Since transistors can be hard to figure out and finicky to work with, there comes a time when it's better to just use a real SWITCH... that is on when it's on, no current or voltage dependence, it's just on, mechanically connected.

A relay is a special kind of mechanical switch that can be switched based upon a current input. Relays almost always have five pins. If you understand what the pins are, you understand the device!

Two pins are attached (within the sealed brick relay) to a coil. When you pass a current through a coil.... voila, it makes a magnetic field. This magnetic field pulls down a steel lever arm within the relay, which makes a mechanical contact between two other pins. Switched! Actually, there are three pins at the power end of a relay – the input power pin, and two possible outputs. One is generally marked NC and the other NO. NC means "Normally Closed" while NO means "Normally Open". "Normally" is when the coil is not energized... and then when the coil is energized, the input power switches and the closed becomes open and vice versa. So the pin diagram is something like this: (BOTTOM VIEW)



Ok, so, when there is no current in the coil, the input power is attached to the NC output, and there's nothing attached to the NO pin. Remember, no current in the coil is what they mean by "normally" . When there IS current in the coil, the mechanical lever inside the device moves and the input power pin is shorted to the NO pin (it becomes closed) and there's nothing attached to the NC pin (it's open!).

Since this is a mechanical switch, you can shunt a LOT of power. A relatively small coil can trip a big switch – a relay that is physically the size of your average "wall wart" dc power supply … may be capable of switching 30 Amps of 240 VAC, for example! Really humongous loads always use relays. Ever wonder what switches are used for the huge things that move railroad tracks in a switchyard, for example? Yup... really big relays.

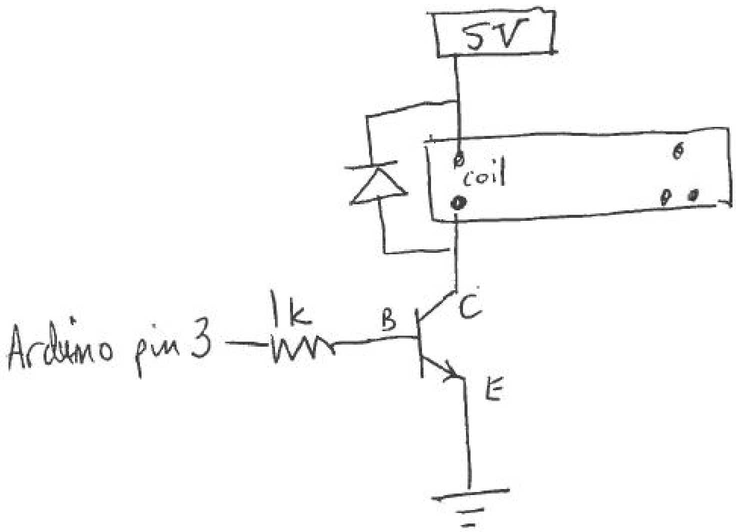
One problem with relays, though, is that even the coil side, which is nominally the "low power" easy part.... can draw a fair bit of current. If you understand that this is a magnetically controlled thing, the solenoid makes a field to suck on the steel lever, this makes sense. It takes some current to make a decent sized magnetic field. So once again, a feeble Arduino can't source enough current to even run the coil.

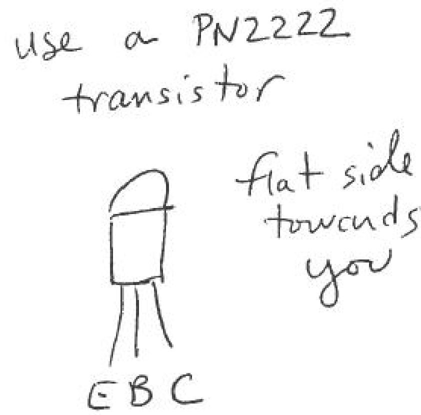
So, we use all the tricks we have. The digital output of the Arduino is used to "turn on" a transistor. The transistor is used to drive the coil. The coil then switches the real power at the other end of the relay.

You can HEAR a relay switch. It goes "kerchunk" when it mechanically switches. Little relays like we use today make a soft little click. Big relays make a very distinct loud clunk. Listen as you debug!

Another problem with relays comes from the very nature of a coil system. When you turn the coil off, no more current.... Faraday comes back to haunt you. The coil itself produces a back emf opposing the change in field. This is a voltage spike going right back up into the whatever circuit you used to energize the coil. This is not good. Output power sources do not like high voltage spikes coming IN to them (they're outputs!) Typically we use a diode rectifier to prevent this spike.

Thus the coil energizing circuit would be:





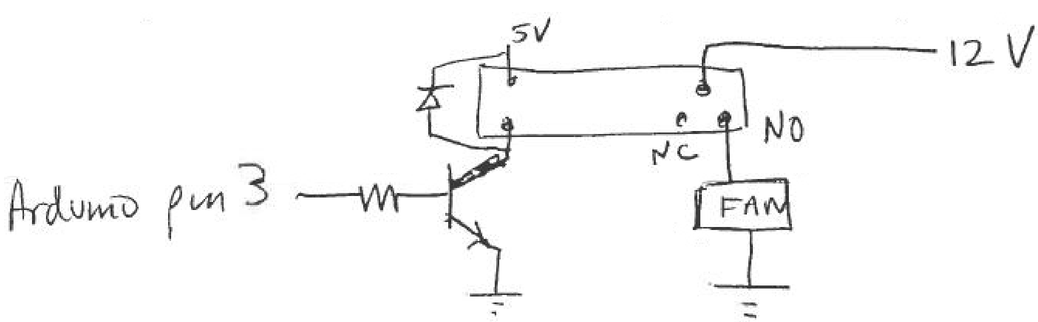
where this coil draws small enough current we can run it from the 5 V power tap on the Arduino board. (for a more current-hungry coil, use a wall-adapter separate DC supply, switched with the transistor as shown above).

The diode should be any power rectifier diode. Make sure it is in the correct orientation, though! Note that we are using the PN2222 general purpose NPN transistor, which can deliver 1 A of current!

Write a little sketch that turns this on and off every second or two. Run it. You should hear the relay clicking.

Change the timing in your sketch so it switches every 20 or 30 seconds (long enough for you to measure something!). Use a DVM to verify how the NO and NC pins are switching – measure ohms from the input power pin to NC or NO.

Set up a bench power supply set to 12 V at any current. Use that as your power to switch, and a little 12 V fan as your test device. Run your sketch. Does the fan turn on and off every 20 or 30 seconds as your relay switches?



This same system can be used to switch “wall power” 110V AC. Note that **AC house wiring can kill you**. Treat this with some respect and BE CAREFUL.

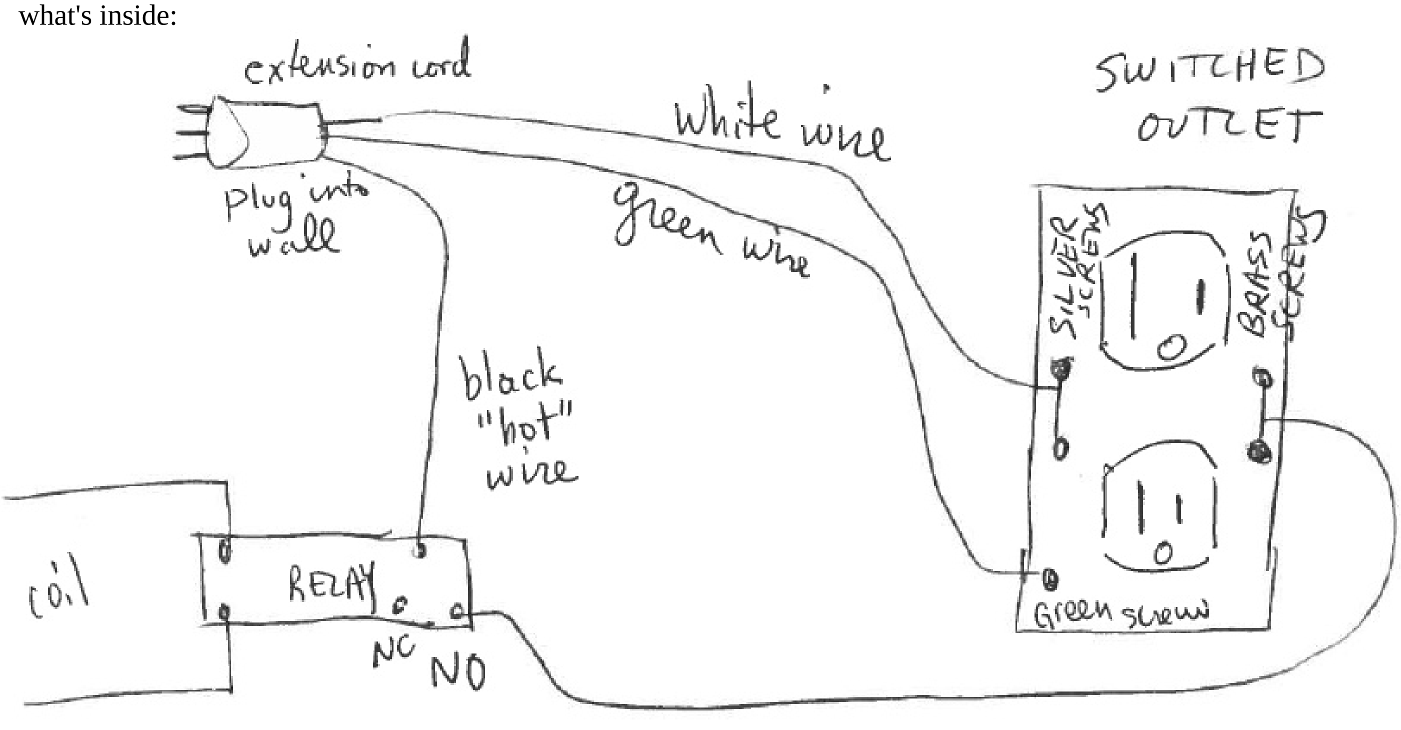
I built a switched outlet for you. Look at a regular outlet – you'll see silver screw terminals, brass (gold) terminals, and a green screw. Cut the female end off an old power cord and split it. You should have a black wire, a white wire, and a green wire.

FOR ALL HOUSE WIRING REMEMBER:

white	=	neutral	=	silver screw terminals
black	=	hot or live side	=	brass screw terminals
green	=	ground	=	green screw terminals

Always SWITCH the hot side (black) with your relay. Permanently wire the white side to the device, which in this case is our switchable outlet (the white wire is neutral anyhow). That way you the outlet (or device) will be truly dead when the relay is not energized; the hot wire has open circuited, and the neutral wire (white) is still connected. If you swap these accidentally, the circuit will still be active even when you THINK it is not (relay not energized). And you will get bit, or worse, by full 110V AC power.

I buried all this wiring – and the relay – in a standard electricians junction box, so its not something you can get your fingers into. This is only sensible, and if you ever build one like this you should do the same! Here's what's inside:



Wire the relay coil wires (the two green wires fished out) to the same circuit used on the previous page. Run your sketch. Now the outlet box switches on and off! Test it by plugging in a lamp.