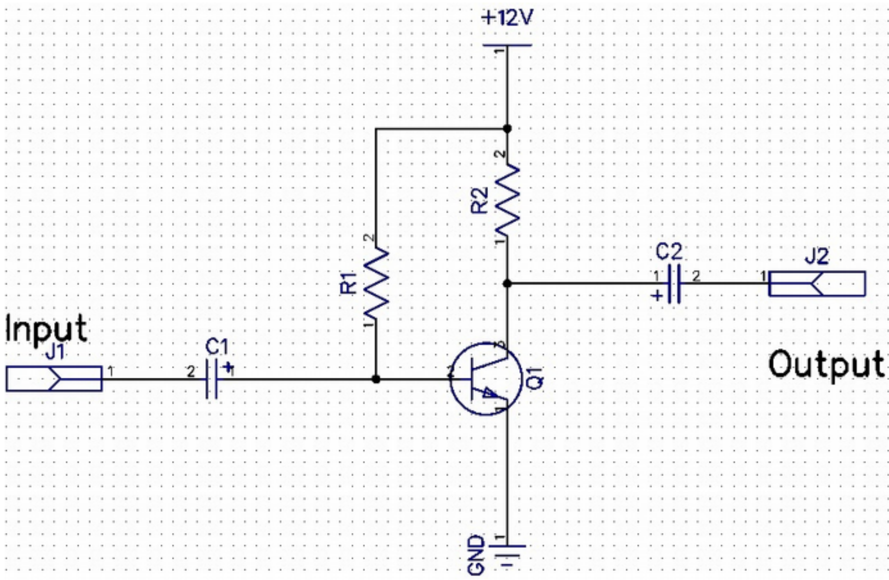
TRANSISTOR AMPLIFIER BIASING
Part 1

1. Very simple biasing

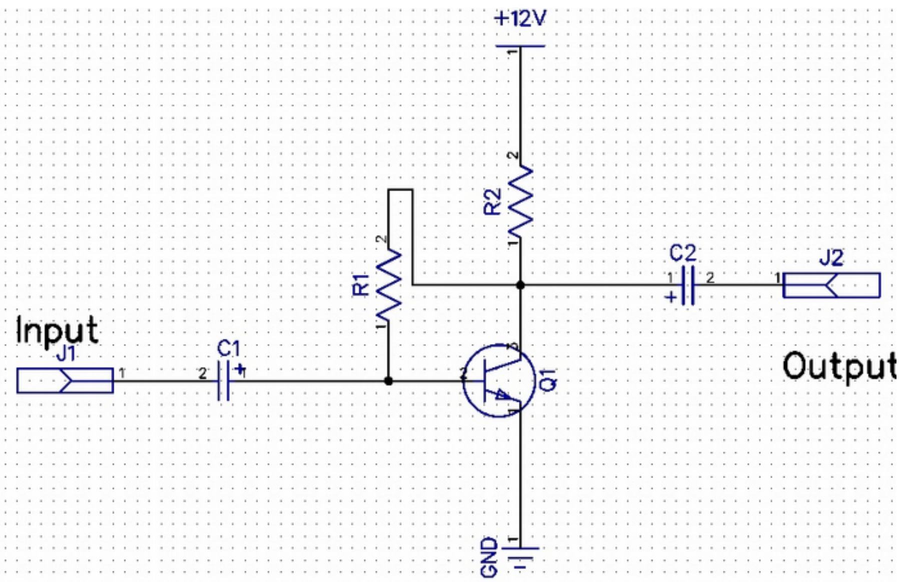


The very simplest biasing is simply to connect a resistor from the positive supply (assuming an NPN transistor like the 2N3904) to the base. A capacitor (C1) can be used to prevent the input AC signal source from “seeing” this voltage. A resistor in the collector circuit (R2) will cause a voltage gain to manifest, and another capacitor (C2) can be used so the output signal doesn’t have any DC to it.

The trick is to select R1 such that the base current which it causes, when amplified by the Hfe of the transistor, results in a voltage drop across the collector resistor of just about half the supply voltage – so the collector is now free to swing all the way UP to the supply, and all the way DOWN nearly to ground – maximum output possible voltage without clipping.

But every transistor is different! And add a little heat or cold, and their gain changes yet again!! So you may have to adjust every circuit individually for that precise transistor, and for the precise temperature at which the user will keep their room…..not a really robust design.

2. Slightly better biasing design



An easier to adjust biasing scheme is to get the biasing voltage for the base pull-up resistor R1 not from the positive supply….but from the COLLECTOR!!

That way, there is a bit of negative DC feedback going on to make the final operating point a little more stable. Here is how it works: If the transistor has HIGHER gain than expected, drawing MORE current through R2, the collector voltage will be LOWER, driving LESS current through R1, and causing a bit LESS base drive than would have otherwise been expected.

This has a decent chance of working. And in fact, we have used this exact circuit as the input signal amplifier for the VOX circuit of a couple dozen of our homebrew sound card isolators and generally the collectors have ended up right about half-way between ground the the +V terminal, right where we wanted them. There is a bit of negative AC feedback also – if you knew the effective "base AC input impedance" (it might be 1000 ohms or so) and in our case R1 was 220K...so about ½ of one percent of the output voltage was negatively fedback to the input….not enough to do much as it would only limit the gain of the circuit to 200...far more than the circuit probably achieved.

The value of the feedback resistor can be guessed at as follows.

Assume the transistor current gain is 100. And Supply is 12V, and you want the collector to quiescently sit at 6 volts. Assume the collector resistor is 5 K, so with 6 volts across it (do you see why?) the collector current is

I = E/R = 6volts/5Kohms = 1.2 milliamps

Since the gain of the transistor is 100 we need 1/100 of that current (12 micro amps) to flow into the base, and it will be fed from 6 volts (the collector) and go into a base that will be at 0.6 volts (the base – emitter is a diode, and it will always be near 0.6 volts when turned on) – so there will be 5.4 volts across it and 12 micro amps through it….sound just like a question from the Technician exam, huh?

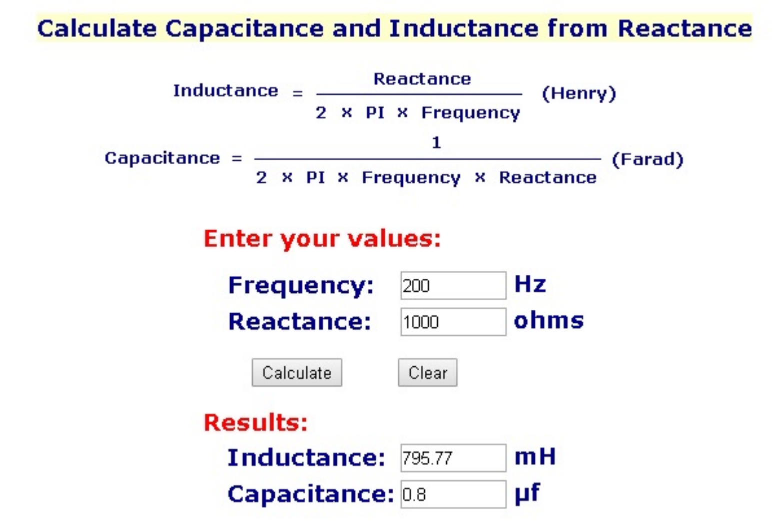
R = E/I = 5.4 / 12 microamps = 450K ohms

Gee, look at that – you just designed a microphone preamp that will work reasonably well for very small signals where the transistor "looks" linear!

What about the two capacitors, C1 and C2? Basically, you need to be sure that their impedance at the lowest frequency of interest (say, 200 Hz) is about equal to the driving or source impedance. The impedance of the base input we assumed was around 1000 ohms, and the impedance of the output is the collector resistor of 5000 ohms…. So if we come up with a capacitor that has about 1000 ohms impedance at 200 Hz it will work just fine for both side – so find a page that does capacitive reactance….

Like: http://www.calculatoredge.com/electronics/reactance.htm

plug in the numbers and you get….



So you need a 0.8 microfarad capacitor, and you can easily purchase a ONE microfarad capacitor and it will work fine. (Guess what – that is how we designed the input audio amplifier for the sound card isolator)

However, this circuit can be improved upon even more – and made even less susceptible to temperature and with a GUARANTEED GAIN.

But that will be for next time!