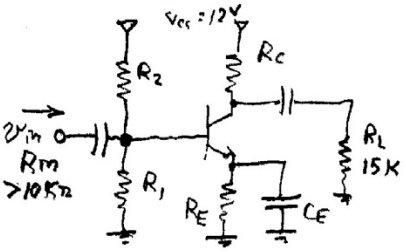
Lab 0 Design Example Simulation results: Rin≥10K, RL=15K, Vcc=12V, Maximize gain (Using a PN2222)

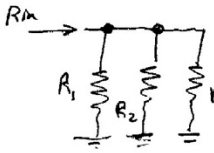
EE252 Electronics 2 | Lab 0 supplement

Problem: Design C.E. amplifier, $V_{cc} = 12V$, $R_L = 15K\Omega$, $R_{in} = 10K\Omega$ (This is key issue.)
Maximize gain. We choose NPN PN2222 assume $\beta = 100$

Circuit:



Design decision: Choose I_C such that $r_\pi \approx 15K$



R_1, R_2 should be "big"

If $r_\pi \approx 15K\Omega$, then Z_{in} should be $> 10K\Omega$

$15K\Omega/A = .026V/I_C$ so $I_C = .026V/15K\Omega = .173mA$
we'll take a chance and let $I_C = .2mA$

So, designing with $I_C = .2mA$:
Choose to follow rule of Thumb that suggests $V_E = \frac{1}{3}V_{cc}$, $V_C = \frac{2}{3}V_{cc}$.

So $V_C = 8V$ $V_E = 4V$ $V_B = 4.7V$ We now calculate R_C, R_E:

$R_C = 4V/.2mA = 20K\Omega$ (std. value)
$R_E = R_C$ since $I_E \approx I_C$ (linear region)

So, if $I_C = .2$ mA, choose to use rule of thumb that $I_{R_1} \approx 10 I_B$. With $\beta = 100$ then $I_{R_1} = .02mA$ so $R_1 = \frac{4.7V}{.02mA} = 235K\Omega$
(we will use 240K standard value.)

Now, $I_{R_2} = I_B + I_{R_1} = .022mA$ $V_{R_2} = 7.3V$

So now $R_2 = 7.3V/.022mA = 332K\Omega$ (Use $330K\Omega$)

Now we can calculate $R_{in} = r_\pi \| R_1 \| R_2 = 13K\Omega \| 240K\Omega \| 330K\Omega$
$R_{in} = 11.89K\Omega$

[We could go back and make I_C larger by maybe 15% and get more gain.]

Gain: $g_m = I_C/V_T = .2mA/.026V = 7.7mS$

$A_v = v_o/v_{in} = -g_m(R_C \| R_L \| r_o)$ ($r_o \to \infty$) (we'll assume r_o negligible)

$= -7.7mS \cdot 8.6K\Omega = -66$

We expect a gain of -65 or 36dB. (That's what we saw in the laboratory.)

We ought to get similar results from simulation.

Note that with $R_S = 0$ (not represented) our gain here is a bit higher than with, say, $R_S = 1K\Omega$ (Or, with our signal generators, 50Ω)

Remarkably - with $R_S = 0$ Transistor β almost doesn't matter! It affects R_{in}, but if gain is measured from v_{in} (rather than v_S) A lower R_{in} doesn't matter much, except it will raise f_H.

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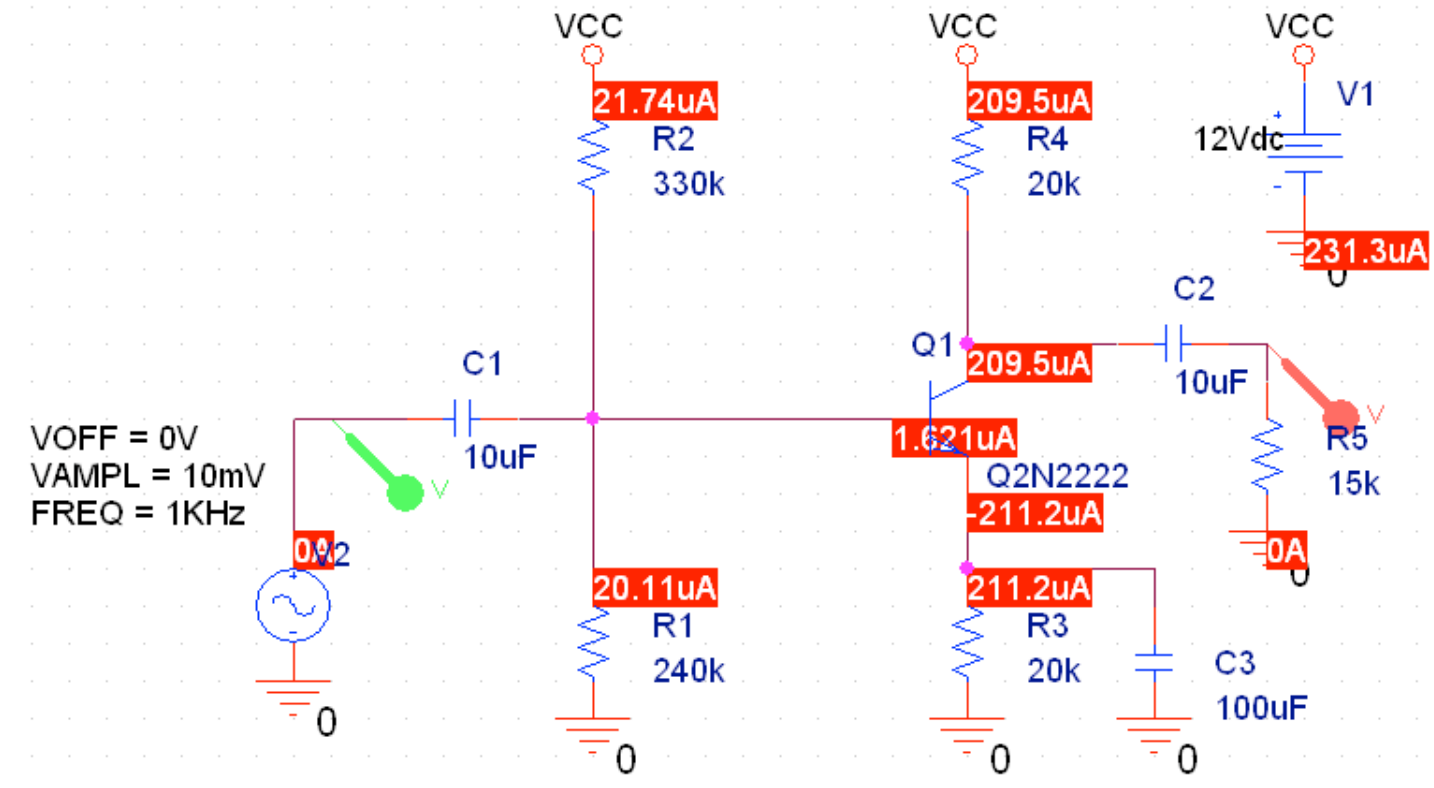
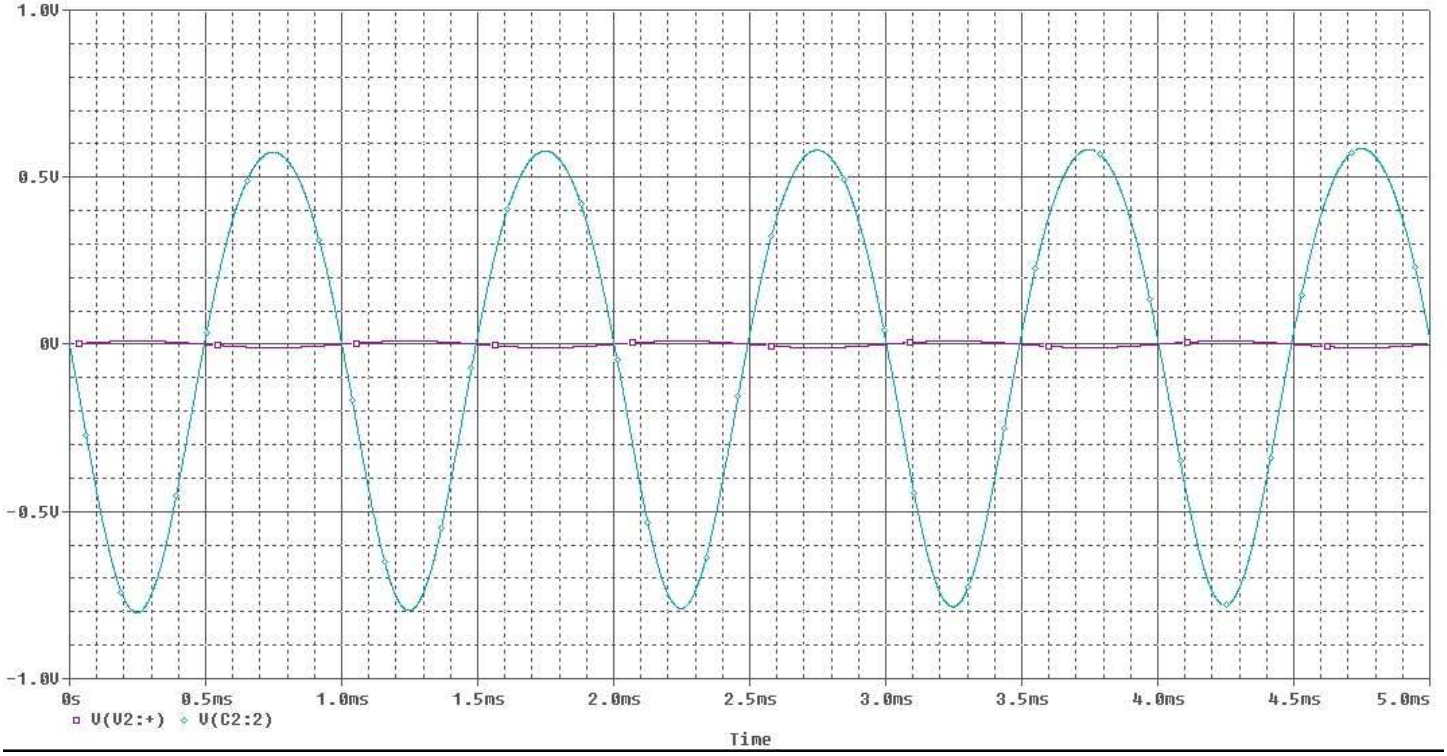


Also: VC=7.809V, VE=4.223V, VB=4.827V

AC Results:



|Av| = vo p-p / vin p-p = 1.37V/20mV = 69.5 (36.8 dB) Phase is 180° - so we are within midband.
The gain would be a perhaps slightly higher at lower input Voltages since we would avoid the distortion seen.