ECGR3131 Project One: BJT Amplifier

Luis Umana

I. Introduction

The purpose of this project is to create a common-emitter amplifier using the Q2N3904 transistor. In order the project to be considered successful, the following requirements are needed in the circuit.

Requirements for the amplifier:

$$Av = V_o/V_i \geq 150V/V \quad (1)$$

$$PowerConsumption = V_{cc*}I_{cc\leq}200mW \quad (2)$$

$$R_L = 5K\Omega \quad (3)$$

$$V_{cc=}18V \quad (4)$$

$$Swing = 12V_(pk - pk) \quad (5)$$

II. DC Analysis

The following section will show the calculations, load lines, and DC Biasing for the DC Analysis. For an "educated guess", the DC Qpoint was assumed to be (7.5V, 5mA) which makes the ACLL 13.5V. The Qpoint and ACLL were used to find RC, aka the collector resistor value.

$$ACLLV = I_c * (R_c||R_L) + VCEQ \quad (6)$$

$$13.5 = 5mA * (R_c||5K\Omega) + 7.5 - -- > R_c = 1579\Omega \quad (7)$$

After Rc has been found, it can be used to find the Vc in Eq. 8.

$$Vc = V_{cc} - I_{cc} * (R_c) \quad (8)$$

$$Vc = 18 - 5mA * (1579) - -- > V_c = 10.105V \quad (9)$$

Vc and Vceq can now be used to find Ve in Eq. 10.

$$V_e = V_c - Vce \quad (10)$$

$$V_e = 10.105 - 7.5 - -- > V_e = 2.605V \quad (11)$$

Ve can be used to find Re. Ib and Ie can easily be found with the current data we have. However, another "educated guess that was made was that B would be 100.

$$I_b = \frac{I_c}{B} - - > \frac{5mA}{100} - - > I_b = 0.00005A \quad (12)$$

$$I_e = I_c +_B = 0.005A + 0.00005A - - > I_e = 5.05mA \quad (13)$$

$$R_e = \frac{2.605V}{5.05mA} - -- > R_e = 515.84 \quad (14)$$

Vb can be found also using Ve in Eq. 15.

$$V_b = V_e + 0.7 - - > 2.605 + 0.7 - - > V_b = 3.305V \quad (15)$$

Once we found our Vb, we can then use it to find R1 and R2. The final "educated guess" was made by assuming that the sum of R1 and R2 is equal to $4000\Omega . Vb = \frac{18*R2}{R1+R2}$(16)

$$3.305 = \frac{18 * R2}{4000} - -- > R2 = 734.44\Omega \quad (17)$$

$$R1 = 4000 - R2 - -- > 4000 - 734.44 - -- > R1 = 3265.56\Omega \quad (18)$$

With all the necessary values calculated, the DC circuit from the calculations was created in Fig. 1.

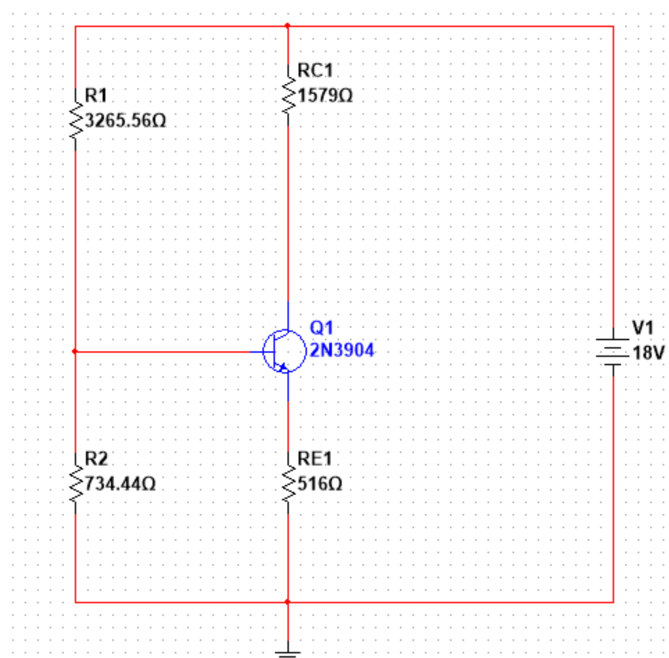

Fig. 1. DC Circuit for common-emitter amplifier

The table 1 shows the difference between the calculated values and the simulated values. Besides Ib, all of components have a percent error less than 1 percent. I'm not exactly sure why the percent is so high, since the calculation and circuit configuration doesn't seem to be incorrect.

TABLE I
DC VOLTAGE AND CURRENTS: CALCULATED VS. SIMULATED

Components	Calculated	Simulated	Error
V_b	3.305 V	3.29 V	-0.4559%
V_c	10.105 V	10.1 V	-0.0495%
V_e	2.605 V	2.58 V	-0.969%
I_b	50 uA	29.3 uA	-70.65
I_c	5 mA	4.97 mA	-0.6036%
I_e	5.05 mA	5mA	-1%

Fig. 2. DC Load Line

III. AC ANALYSIS

IV. RESULTS

This section shows all of the plots created from the simulation of the project.

Figure 5 shows the gain magnitude and phase vs the frequency. All capacitors used were 1uF.

Figure 6 shows the AC Sweep max gain at 1khz. The frequency was used when creating the transient model of the circuit.

The plot shown in figure 7 is the Rinput vs Frequency graph. This shows the effects that our capacitors have on the circuit.

The plot shown in figure 8 is the Rout vs frequency. While the magnitude looks the same, the phase in the frequency have a slight difference of where it stabilizes and starts to fall.

The plot shown in figure 9 is the transient of the circuit.

V. CONCLUSION

Based on the calculations of the circuit and the minor percent errors, the amplifier meets all of the requirements of the project. The percent error can easily be explained based on rounding errors, the settings for creating graphs, as well as the value of capacitors. The capacitor shouldn't make much of a difference in the simulation however, hand calculations ignore capacitors values while the simulation include those values.

The swing becomes unsymmetrical between 6V and 6.25V due to the safety barrier of .25V used when creating the amplifier.

The Q point was assumed with an "educated guess", however the ACLL voltage was decided based on the swing voltage. Once the Q point and ACLL were established, they were used in EQ. 6 and Eq. 7 to find RC. By finding RC, the rest of the data can be calculated to find the necessary components of the circuit amplifier and meet the requirements.

TABLE II
AC VOLTAGE AND CURRENTS: CALCULATED VS. SIMULATED

Components	Calculated	Simulated	Error
Gain	200 V	234 V	-17%

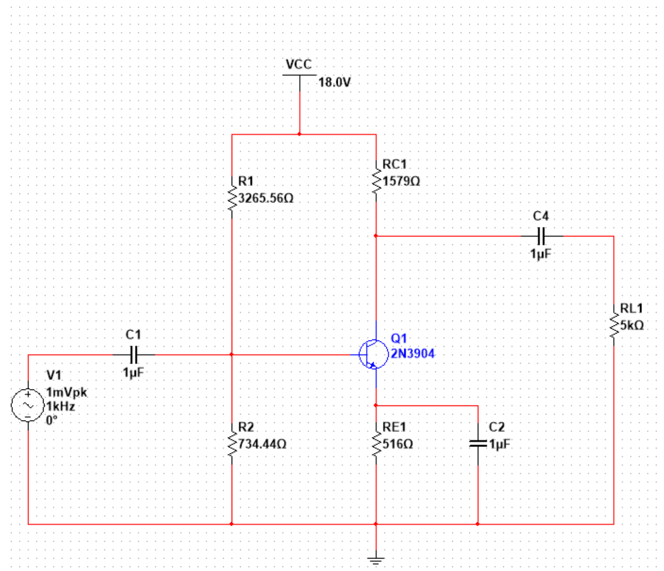

Fig. 3. Complete common-emitter amplifier

REFERENCES

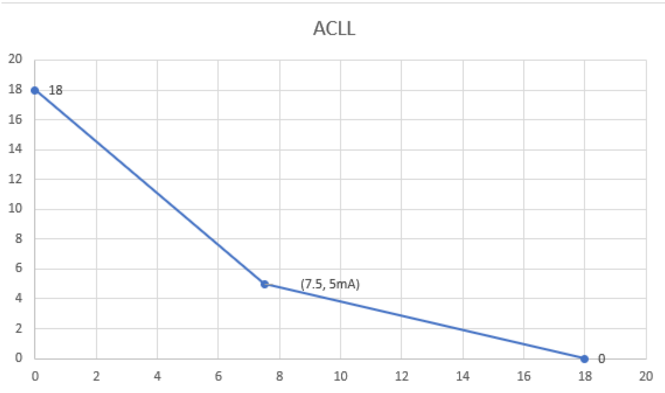

Fig. 4. Complete common-emitter amplifier

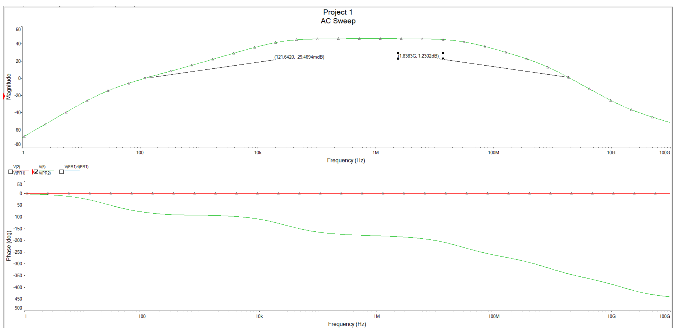

Fig. 5. Gain Magnitude vs Frequency and Phase vs Frequency

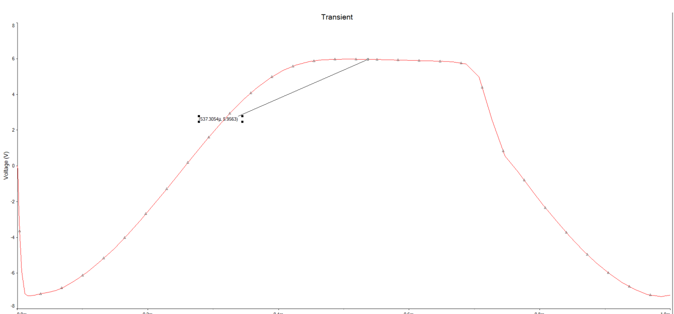

Fig. 6. Plot for Max Gain

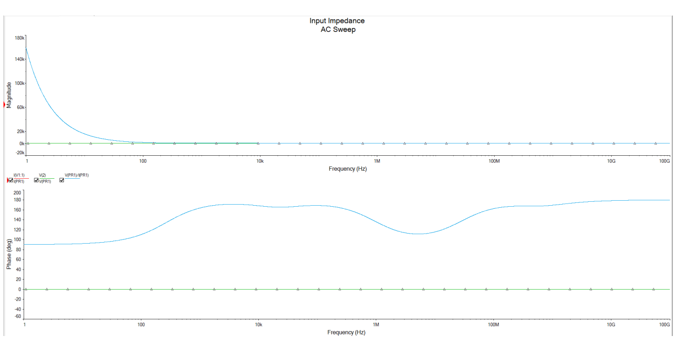

Fig. 7. Plot of Rinput and Phase vs Frequency

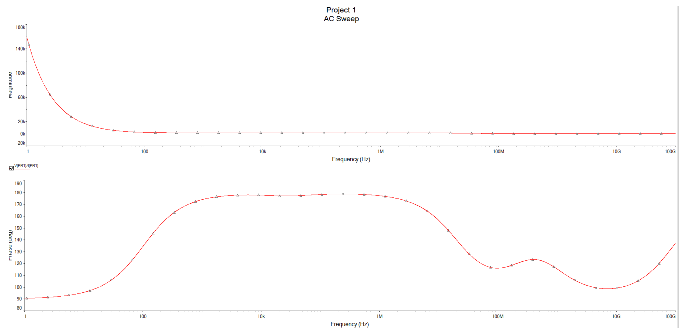

Fig. 8. Plot of R out and Phase vs Frequency

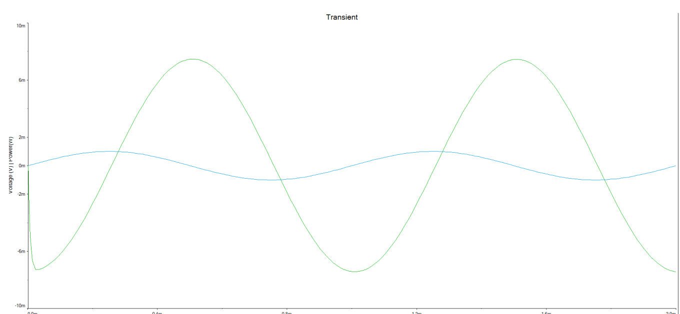

Fig. 9. Transient