ECGR3131 Project TWO: MOSFET Amplifier

Luis Umana

I. Introduction

The purpose of this project is to make a MOSFET Amplifier using a CD4007UBE N-MOS transistor. Since there was no real specification on the design of the circuit, the circuit was designed as a single stage common-source amplifier. The requirements below were need to meet the requirements of the circuit.

Requirements for CD4007UBE:

$$V_T = 1.40V \tag{1}$$

$$\mu_o C_{ox}(W/L) = 600\mu A/V^2 \tag{2}$$

$$|V_A| = 200V \tag{3}$$

Requirements for the amplifier:

$$Av = V_o/V_i \geq 10V/V \tag{4}$$

$$PowerConsumption = V_{DD*}I_{DD\leq}75mW \tag{5}$$

$$R_L = 20K\Omega \tag{6}$$

$$V_{DD=}15V \tag{7}$$

$$Swing = 7V_(pk - pk) \tag{8}$$

II. DC Analysis

The following section will show the calculations, load lines, and DC Biasing for the DC Analysis. Similar to the last project, an "educated guess" for the DC Qpoint was assumed to be (10.5V, 5mA) which makes the ACLL 14V. The steps for the math was basically the same. The Q-point and ACLL were used to find RC, aka the collector resistor value.

$$ACLLV = I_D * (R_D||R_L) + VCEQ \tag{9}$$

$$14 = 5mA * (R_D||20K\Omega) + 10.5 - -- > R_D = 725.39\Omega \tag{10}$$

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

$$VD = V_{DD} - I_{cc} * (R_c) \tag{11}$$

$$VD = 15 - 5mA * (725.39) - -- > V_D = 11.37V \tag{12}$$

VD and Vdeq can now be used to find VS in Eq. 10.

$$V_S = V_D - VDe \tag{13}$$

$$V_S = 11.37 - 10.5 - -- > V_S = 0.87 \tag{14}$$

VS can be used to find RS. IG and IS can easily be found with the current data we have. However, another "educated guess that was made was that B would be 100.

$$I_G = \frac{I_D}{B} - - > \frac{5mA}{100} - - > I_G = 0.00005A \tag{15}$$

$$I_S = I_D + I_G = 0.005A + 0.00005A - - > I_S = 5.05mA \tag{16}$$

$$R_S = \frac{0.87V}{5.05mA} - -- > R_S = 172.28 \tag{17}$$

VG can be found also using VS in Eq. 15.

$$V_G = V_S + 0.7 - - > 0.87 + 0.7 - - > V_G = 1.57 \tag{18}$$

Once we found our VG, 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 3469Ω.$Vb = \frac{15*R2}{R1+R2}$(19)

$$3.305 = \frac{15 * R2}{3469} - -- > R2 = 363.09\Omega \tag{20}$$

$$R1 = 4000 - R2 - -- > 3469 - 363.09 - -- > R1 = 3265.56\Omega \tag{21}$$

The DC circuit in Fig. 1. were created based on the calculations.

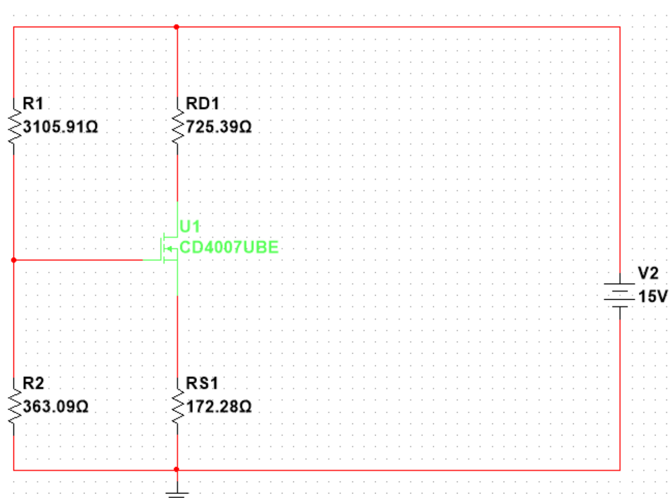

Fig. 1. DC Circuit for common-source MOSFET

The measurements of the DC circuit was also included this time in the project, since unlike the last project, the measurements seem completely different compared to my actual calculated results. This error could have either been made, due to poor placement of the probes, a possible design flaw, or an error in my calculations.

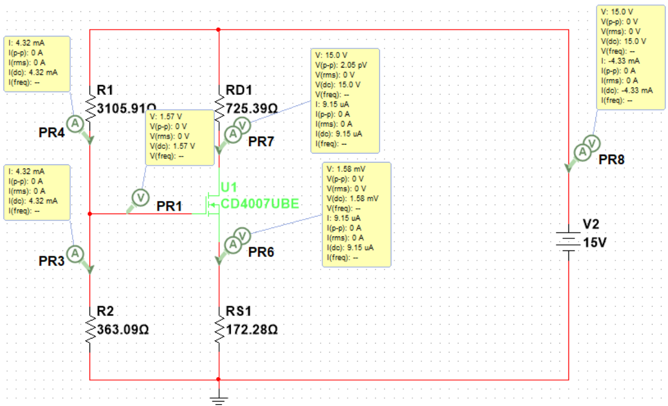

Fig. 2. DC Circuit Measurements

TABLE I
DC Voltage and Currents: Calculated vs. Simulated

Components	Calculated	Simulated	Error
V_G	1.57 V	1.57 V	0%
V_D	11.37 V	2.05 pV	7.31*10^{1}2%
V_S	0.87 V	1.58 mV	98%
I_G	50 uA	9.15 uA	81.7%
I_D	5 mA	4.32 mA	13.6%
I_S	5.05 mA	4.32 mA	14.5%

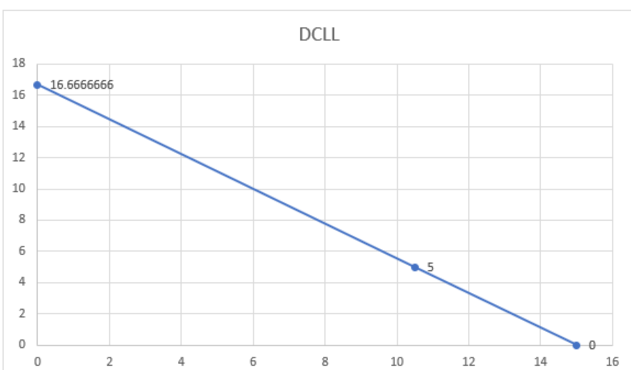

Fig. 3. DC Load Line

III. AC Analysis

TABLE II
Ac Voltage and Currents: Calculated vs. Simulated

Components	Calculated	Simulated	Error
Gain	-3.42 V	-4.21 V	29.93%

IV. Results

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

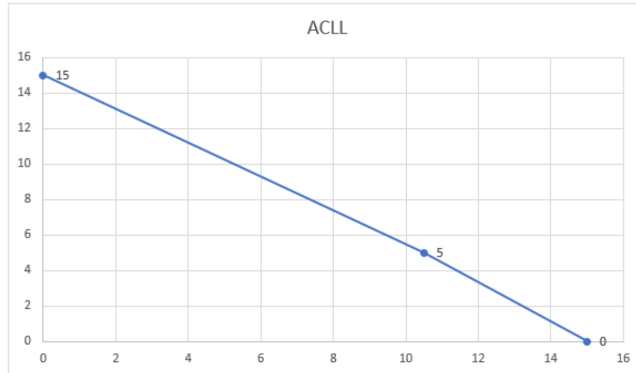

Fig. 4. AC Load Line

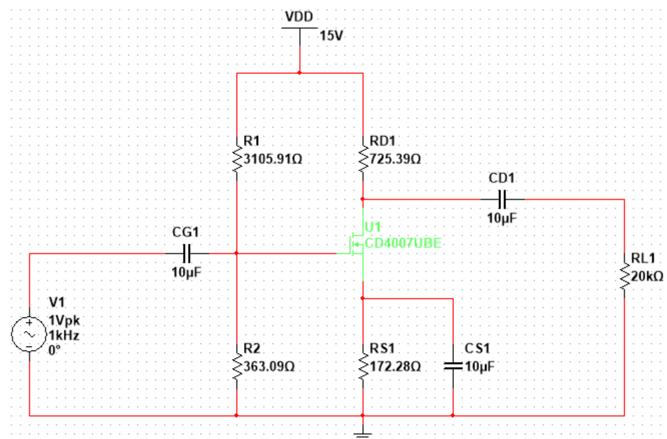

Fig. 5. DC Circuit for common-source MOSFET

Figure 6 shows the gain magnitude and phase vs the frequency.

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. Areas for Future Research/Improvement

A better improvement that needs to be made would be to improve the interface of MULTISIM as well as, update the components of the database in order to reduce the chance of user error. Nowadays, it seems like the most common use for a MOSFET would be used in automotive electronics, such as a Tesla. A possible research tech companies could perform would be if they could ultiize MOSFET setups to improve robots movements. Companies like Boston Dynamics, are attempting to build robots for every day to day work, to improve the efficiency of production. They have built robots for construction and warehouse jobs, so they could try to investigate to see if a MOSFET focused robot can have a better maximum speed then their current robots.

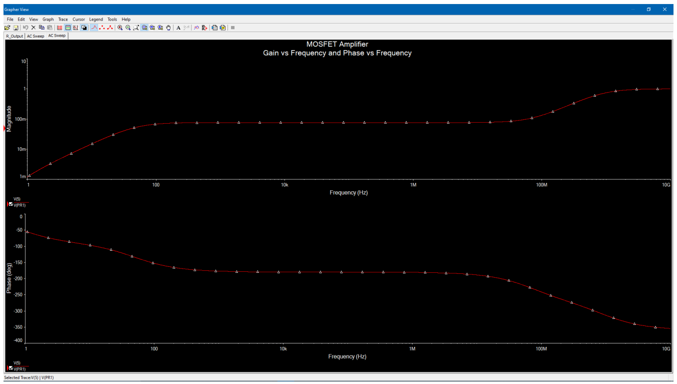

Fig. 6. Gain Magnitude vs Frequency and Phase vs Frequency

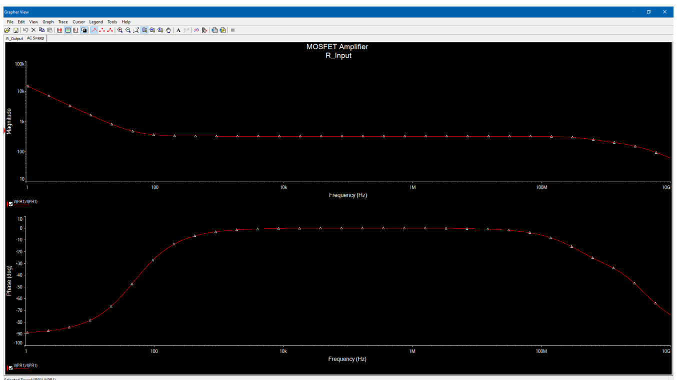

Fig. 7. Plot of Rinput and Phase vs Frequency

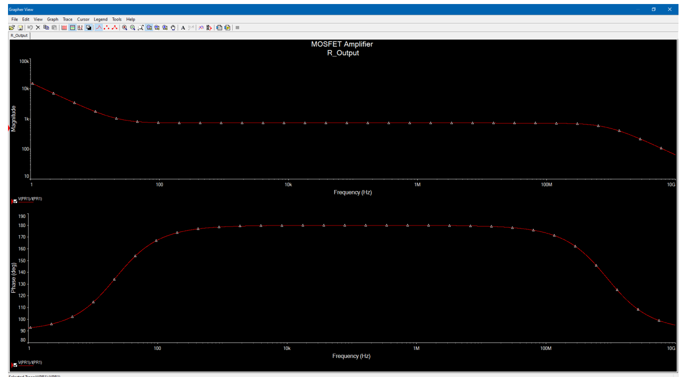

Fig. 8. Plot of R out and Phase vs Frequency

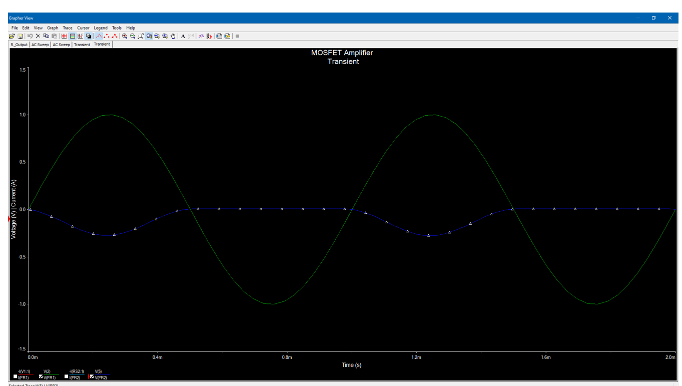

Fig. 9. Transient

VI. Conclusion

It's hard to say whether the project was a success, or not due to the large percent errors in the DC analysis, however the AC circuit does seemed to have proper readings. The percent error be caused by multipe things such as rounding errors, setting for the MOSFET, placement of the probes, and a possible error in the chosen Q point.

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. 9 and Eq. 10 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.