Lab 10 - NPN Common-emitter Amplifier

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Introduction

In this lab we are going to practice designing a common-emitter amplifier by biasing in the active region targetting a specific gain.

We want to design the circuit such that the gain is at least $A_V = -200\text{V/V}$, and $I_C = 1$ mA.

We are going to use $V_+ = -V_- = 15$ V, $R_L = 10$ kΩ, $R_B = 10$ kΩ. We can assume that $\beta = 160$ for this transistor.

`../circuit/circuit.pdf`

Figure 1: The circuit we use in the lab.

DC Analysis

For the DC analysis, we can assume that the capacitors act as open circuits, and so we can remove everything but the transistor, the sources, and the resistors R_C, R_E, and R_B.

Knowing that $I_B = \frac{I_C}{160}$, we can find that $I_B = 6.25$ µA, and as such $I_E = 1.00625$ mA. With $R_B = 10$ kΩ, we find that $V_B = I_B \cdot R_B = 0.0625$ V.

$V_E = V_B - 0.7$ V using the constant drop model, so $V_E = -0.6375$ V. This leads us to our R_E which we can find with $R_E = \frac{VE - V_{EE}}{I_E} = 14.273$ kΩ.

This concludes our DC analysis, we need to do the AC analysis to determine a value for R_C.

AC Analysis

For AC analysis we can replace the capacitors with short circuits, and assume that both of the sources are grounded.

We can find the value for g_m with $g_m = \frac{I_C}{V_T} = 0.0386$ A/V.

We can now also find R_π. $R_\pi = \frac{\beta}{g_m} = \frac{160}{g_m} = 4.144$ kΩ.

The V_{sig} to V_i ratio is shown by

The expression for $A_v = \frac{V_i}{V_o}$ can be shown by $A_v = -g_m(R_C \| R_L)$.

With all of those values known, besides R_C, we can find that $R_C \| R_L = 5181\ \Omega$, and accordingly $R_C = 10.753$ kΩ.

This leads us to find that the value for V_C is 4.247 V, which lines suggests that we are in the active region.

The output resistance R_o that is seen by the load is just $R_o = R_c$.

As always we needed to combine resistors in separate networks to find the resistor values. They are shown in Table 3.

Simulation Results

We built the circuit in multisim and found these values for the simulation.

	Simulation
V_{BE}	0.72 V
V_{CE}	5.10 V
I_C	0.992 mA
I_B	7.11 µA
I_E	0.994 mA

Table 1: Simulation results.

We found an amplification of $A_v = -176.9$ V/V.

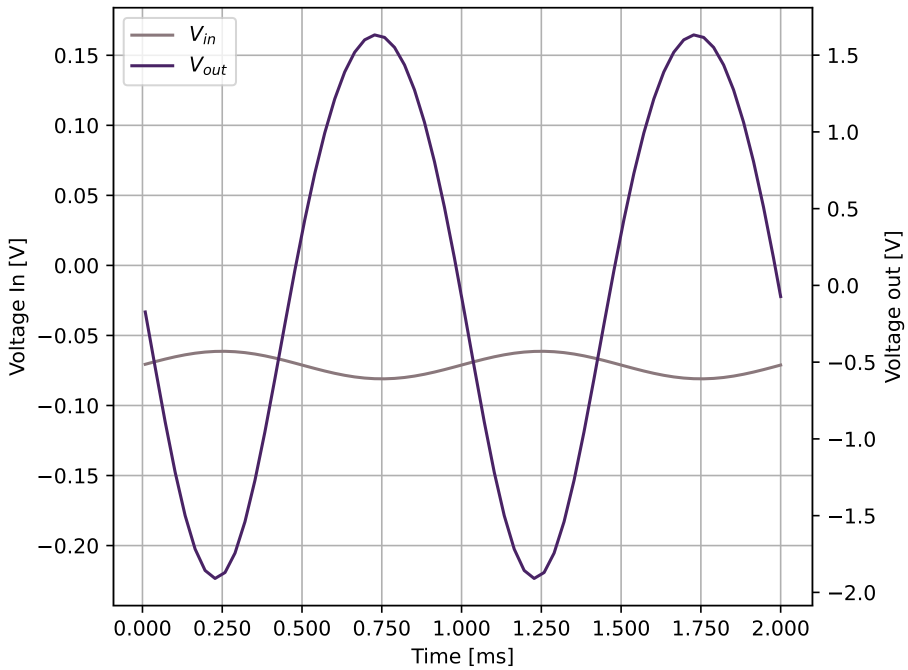

Figure 2: Simulation Results

Measurement Results

	Active Mode
V_{BE}	0.78 V
V_{CE}	5.08 V
I_C	1.01 mA
I_B	4.10 µA
I_E	1.016 mA

Table 2: Measurement results.

Calculated Resistor	Equivalent Resistor	Measured Resistor	
10 kΩ	10 kΩ	9.90 kΩ	R_B
10.752 kΩ	10.680 kΩ 10 kΩ 680 Ω	10.640 kΩ 14.82 kΩ 669 Ω	R_C
14.273 kΩ	14.347 kΩ 15 kΩ 330 kΩ	14.441 kΩ 14.77 kΩ 327 kΩ	R_E
10 kΩ	10 kΩ	9.85 kΩ	R_L

Table 3: Resistors.

Post-Measurement Exercise

We found that $R_L = 1$ MΩ we got 7.52 V_{pp}, and with $R_L = 6.8$ kΩ we got 3.3 V$_{pp}$.