9.1 Overview

You will design a common-base amplifier in matlab, simulate it in Cadence, build the circuit, and measure the voltage gain of the amplifier.

9.2 Matlab Calculation

1. The specifications for the common-base amplifier are shown below
   - $R_S=50 \, \Omega$ ($R_S$ is the internal resistance of the function generator.)
   - $R_{in}=50 \, \Omega$ ($R_{in}$ is the resistance into the emitter of the BJT.)
   - $A_V=10$
   - $I_1 = 40I_B$
   - $V_{CC} = 9V$
   - $V_{in,m} = 50 \, mV$
   - $f = 100 \, KHz$
2. Assume the 2N3904 transistor to have a $\beta = 150$ and an $I_S$ of 6.734 fA.

3. Determine $g_m$.

$$g_m = \frac{1}{R_{in}} \quad (9.1)$$

4. Determine $I_C$ from the $g_m$ specification.

$$g_m = \frac{I_C}{V_T} \quad (9.2)$$

5. Determine $R_E$. Assume that $R_E = 10R_{in}$.

6. Determine $R_C$. ($A_V = V_{out}/V_{in}$)

$$A_v = g_m R_C \quad (9.3)$$

7. Calculate $V_{BE}$.

$$V_{BE} = V_T \ln\left(\frac{I_C}{I_S}\right) \quad (9.4)$$

8. Calculate the voltage at $V_B$.

$$V_B = V_{BE} + I_C R_E \quad (9.5)$$

9. Determine $I_B$ from $\beta$ and $I_C$.

10. Determine $I_1$ given $I_B$. 
11. Determine $R_1 + R_2$ from $V_{CC}$ and $I_1$. ($I_B$ is ignored!)

$$I_1 = \frac{V_{CC}}{R_1 + R_2} \quad (9.6)$$

12. Determine $R_2$ from $V_B$.

$$V_B = \frac{R_2}{R_1 + R_2} V_{CC} \quad (9.7)$$

13. Determine $R_1$ from $R_1 + R_2$ and $R_2$.

14. Design the value of $C_1$ so that the impedance of the capacitor is 15 times less than $R_{in}$.

$$|\frac{1}{\omega C_1}| = \frac{1}{15g_m} \quad (9.8)$$

15. Design the value of $C_b$ so that the impedance of the capacitor is 20 times less than $R_{in}$.

$$|\frac{1}{\omega C_b(\beta + 1)}| = \frac{1}{20g_m} \quad (9.9)$$

16. Calculate the gain of the amplifier from $V_{in}$ to $V_{out}$.

$$A_V = \frac{R_C}{\frac{1}{g_m}||R_E} \quad (9.10)$$

17. Simulate the circuit in Cadence.

18. Submission checklist

- A table summarizing calculated and simulated values of $I_C$, $V_{BE}$, $V_B$, $I_B$, $I_1$, $V_{Re}$, $V_{ReC}$ and $A_V$.
- Simulated $V_{in}$ and $V_{out}$.

9.3 Implementation

1. Build the circuit in the lab.

2. Measure the current in the $R_C$ by dividing $V_{Re}$ by $R_C$.

3. Measure the DC voltage at the base of the transistor.

4. Measure $V_{Re}$

5. Measure the amplitude of $V_{in}$ and $V_{out}$ on the oscilloscope.
9.4 Submission checklist

- A table summarizing simulated and measured values of $I_C$, $V_{BE}$, $V_B$, $I_B$, $I_1$, $V_{RE}$, and $A_V$. (10 points)
- Measured plot of $V_{in}$ and $V_{out}$. (10 points)

9.5 Extra Credit

1. The amplifier that we designed suffers from effects of distortion. The distortion stems from the fact the $R_C$ is used to establish both the collector voltage and the gain of the amplifier. How would you decouple the requirement of the collector voltage from the gain of the amplifier with a capacitor?