EE315 - Electronics Laboratory

Experiment 4
BJT Small Signal Analysis

Preliminary Work

1.a) Calculate $\mathbf{A_V}$, $\mathbf{A_i}$, $\mathbf{R_{in}}$, and $\mathbf{R_{out}}$ on the circuit given in Figure **1**. Assume that $\mathbf{C_{Ci}}$ and $\mathbf{C_{Co}}$ behave as open circuit for DC signals and as short circuit for AC signals.

1.b) Determine limits of the signal source, v_S, for the transistor to remain in forward-active region.

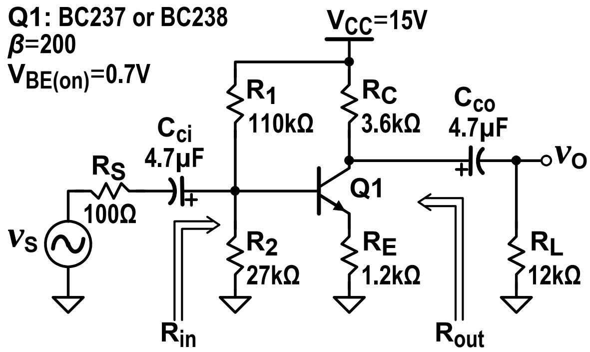

Figure 1. Common-emitter amplifier

2.a) Calculate $\mathbf{A_V}$, $\mathbf{A_i}$, $\mathbf{R_{in}}$, and $\mathbf{R_{out}}$ on the circuit given in Figure **2**. Assume that the coupling capacitors, $\mathbf{C_{Ci}}$ and $\mathbf{C_{Co}}$, behave as open circuit for DC signals and as short circuit for AC signals.

2.b) Determine limits of the signal source, v_S, for the transistor to remain in forward-active region. (Hint: AC current on $\mathbf{R_L}$ will be added onto the quiescent emitter current.)

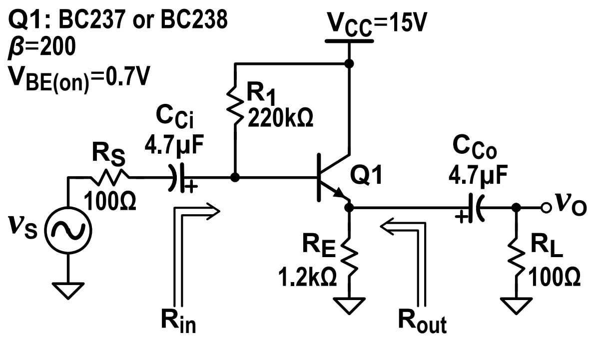

Figure 2. Common-collector amplifier (emitter follower)

Procedure

1. Build the circuit given in Figure 1. Use the function generator to obtain **1 Vp-p**, **1 kHz** as v_S. Note the polarity of the capacitors on the circuit diagram.

1.a) Measure the voltage gain, $\mathbf{A_V}$. Use the oscilloscope in X-Y mode, probing v_S on Ch-1 (X) and v_O on Ch-2 (Y).

$\mathbf{V_{Sp\text{-}p}}$ = $\mathbf{V_{Op\text{-}p}}$ = $\mathbf{A_V}$ =

1.b) Determine the current gain, $\mathbf{A_i}$, by measuring the peak-to-peak AC voltages across $\mathbf{R_S}$ and $\mathbf{R_L}$.

$\mathbf{V_{RSp\text{-}p}}$ = $\mathbf{V_{RLp\text{-}p}}$ =

$\mathbf{I_{Sp\text{-}p}}$ = $\mathbf{I_{Lp\text{-}p}}$ = $\mathbf{A_i}$ =

1.c) Disconnect $\mathbf{R_L}$ and measure the input resistance, $\mathbf{R_{in}}$. Use the oscilloscope in X-Y mode, probing i_S (voltage across $\mathbf{R_S}$) on Ch-1 (X) and v_S on Ch-2 (Y). Note that, the two oscilloscope channels must share a single, common node for proper ground connection.

$\mathbf{V_{Sp\text{-}p}}$ = $\mathbf{V_{RSp\text{-}p}}$ = $\mathbf{I_{Sp\text{-}p}}$ = $\mathbf{R_{in}}$ =

1.d) Measure peak-to-peak output voltage while $\mathbf{R_L}$ is disconnected. Connect a **4.7 kΩ** variable resistor in place of $\mathbf{R_L}$, and adjust the variable resistor to obtain half the output voltage measured without any load. Measure the value of variable resistor that will give the $\mathbf{R_{out}}$ of the amplifier.

$\mathbf{V_{Op\text{-}p(NoLoad)}}$ = $\mathbf{R_{out}}$ =

1.e) Find the maximum peak v_S amplitudes before the transistor goes into cut-off or saturation. Compare the results with your calculations in the preliminary work.

$\mathbf{V_{Speak(cut\text{-}off)}}$ = $\mathbf{V_{Speak(sat)}}$ =

1.f) Connect a **4.7 μF** capacitor in parallel to $\mathbf{R_E}$. Make sure that the polarity of the capacitor matches the DC voltage polarity on $\mathbf{R_E}$. Measure the voltage gain, $\mathbf{A_V}$, again as described in step **1.a**.

$\mathbf{V_{Sp\text{-}p}}$ = $\mathbf{V_{Op\text{-}p}}$ = $\mathbf{A_V}$ =

1.g) Draw the small signal model of the common-emitter amplifier with the capacitor in parallel to $\mathbf{R_E}$, and calculate the voltage gain, $\mathbf{A_V}$, based on your model.

2. Build the emitter-follower circuit given in Figure **2**. Verify that the function generator output is still set to **1 Vp-p**, **1 kHz**, and repeat the steps **1.a**, **1.b**, and **1.c**.

2.a) Measure the voltage gain, $\mathbf{A_V}$.

$\mathbf{V_{Sp\text{-}p}}$ = $\mathbf{V_{Op\text{-}p}}$ = $\mathbf{A_V}$ =

2.b) Determine the current gain, $\mathbf{A_i}$.

$\mathbf{V_{RSp\text{-}p}}$ = $\mathbf{V_{RLp\text{-}p}}$ =

$\mathbf{I_{Sp\text{-}p}}$ = $\mathbf{I_{Lp\text{-}p}}$ = $\mathbf{A_i}$ =

2.c) Disconnect $\mathbf{R_L}$ and measure the input resistance, $\mathbf{R_{in}}$.

$\mathbf{V_{Sp\text{-}p}}$ = $\mathbf{V_{RSp\text{-}p}}$ = $\mathbf{I_{Sp\text{-}p}}$ = $\mathbf{R_{in}}$ =

2.d) Increase v_S amplitude to **2.0 Vp-p** and observe v_O on the oscilloscope. How do you explain the distortion in the v_O waveform?

2.e) Find a way to restore the v_O waveform while keeping v_S amplitude at **2.0 Vp-p**, and $\mathbf{R_L = 100\ \Omega}$. Explain how you can restore the v_O waveform.

2.f) Set the function generator output back to **1 Vp-p**, and measure the output resistance, $\mathbf{R_{out}}$. You should use a smaller variable resistor such as **100 Ω** to obtain a better precision with emitter-follower. Make sure that the output waveform is not distorted while you measure $\mathbf{R_{out}}$.

$\mathbf{V_{Op\text{-}p(NoLoad)}}$ = $\mathbf{R_{out}}$ =