bjt_ce_amp_1.sqproj

Description

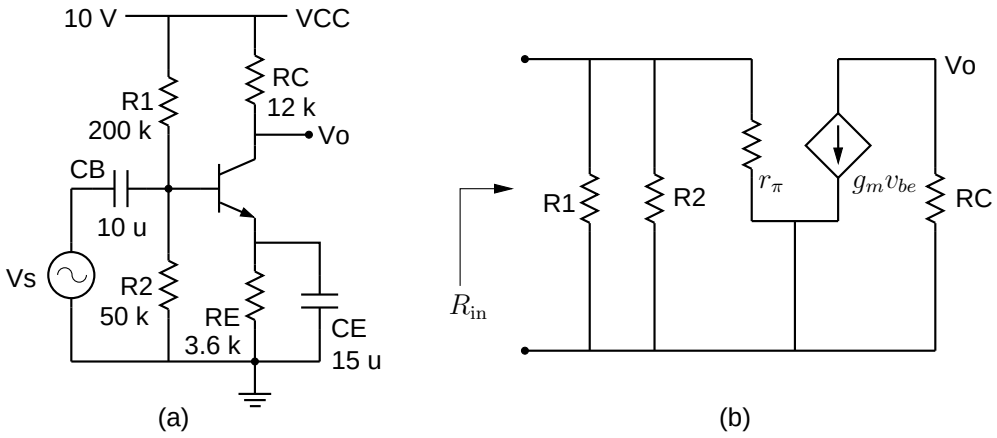

Figure 1: (a) BJT common-emitter amplifier, (b) small-signal equivalent circuit.

The purpose of this exercise it to find the input resistance of a common-emitter amplifier shown in Fig. 1 (a) in the mid-band frequency regime, i.e., the small-signal resistance as seen by the source Vs in the mid-band regime. The small-signal equivalent circuit of the amplifier is shown in Fig. 1 (b) from which R_{in} is seen to be $R_1 \parallel R_2 \parallel r_\pi$. Our goal is to verify this by simulation.

The small-signal circuit of the amplifier can be represented by that shown inside the dashed rectangle in Fig. 2. Let us connect an external source of constant magnitude and frequency (in the mid-band range) at the input through a series resistance R_s. The output voltage is,

$$v_o = A_V \, \frac{R_{\text{in}}}{R_s + R_{\text{in}}} \, v_s \, . \tag{1}$$

If $R_s \to 0\,\Omega$, $v_o \to A_V \, v_s$, and if $R_s = R_{\text{in}}$, $v_o = A_V \, v_s/2$. This gives us the following procedure for finding R_{in}:

1. Vary R_s from $0\,\Omega$ (or a negligibly small value) to a large value (say, 10 times the expected value of R_{in}), and plot $|\mathbf{V}_o|$ versus $\log R_s$.

2. Denote the maximum value of $|\mathbf{V}_o|$ by V_m. From the plot, find R_s for which $|\mathbf{V}_o|$ is $V_m/2$. The resistance thus obtained is the same as R_{in}.

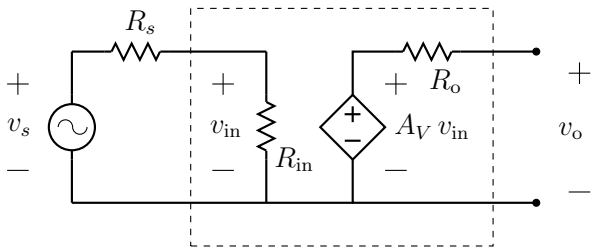

Figure 2: Equivalent representation of the circuit in Fig. 1 (b).

Exercise Set

1. Perform DC simulation of the amplifier and obtain the DC values, I_B and I_C. Compute $\beta = I_C/I_B$. Note that this β value may be different than the "forward β" parameter (`bf`) of the transistor.

2. Compute $r_\pi = \beta/g_m = \beta\, V_T/I_C$.

3. Compute the expected value of $R_{\text{in}} = R_1 \parallel R_2 \parallel r_\pi$.

4. Obtain the gain versus frequency response of the amplifier, and find the midband range.

5. Set the frequency in the midband range. Obtain R_{in} by simulation, as described above, and compare it with its expected value.

6. How will R_{in} change if C_E is removed? Verify by simulation.