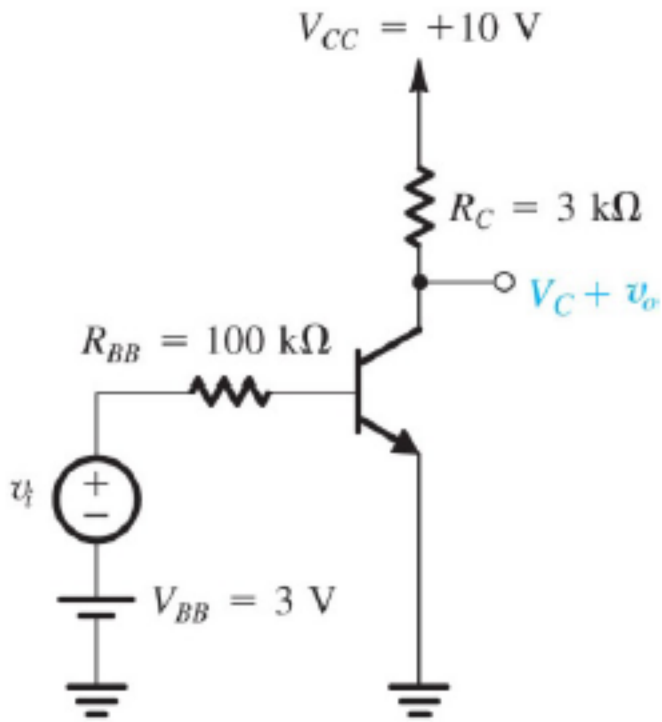
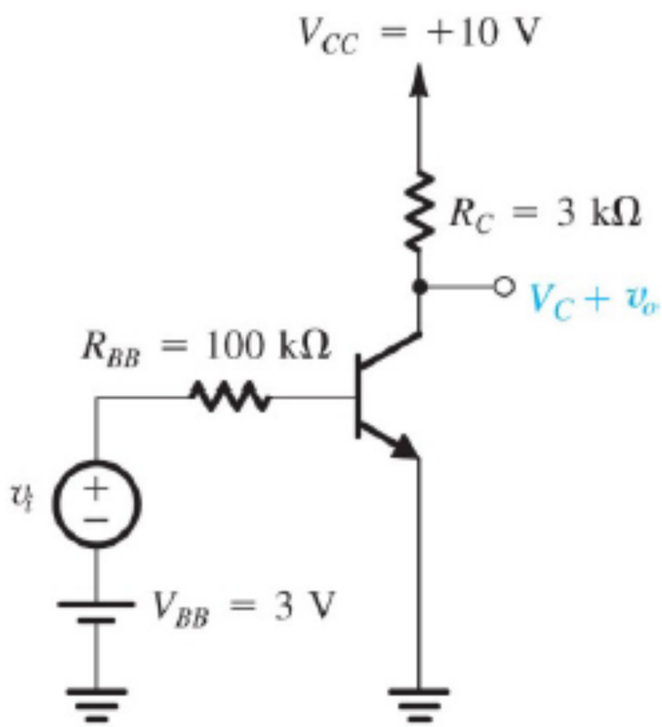
T_5_1 Analyze the BJT transistor amplifier shown below. Determine the voltage gain v_o/v_i. Assume $\beta = 100$ and ignore the Early (base-width modulation) effect ($V_A = \infty$).

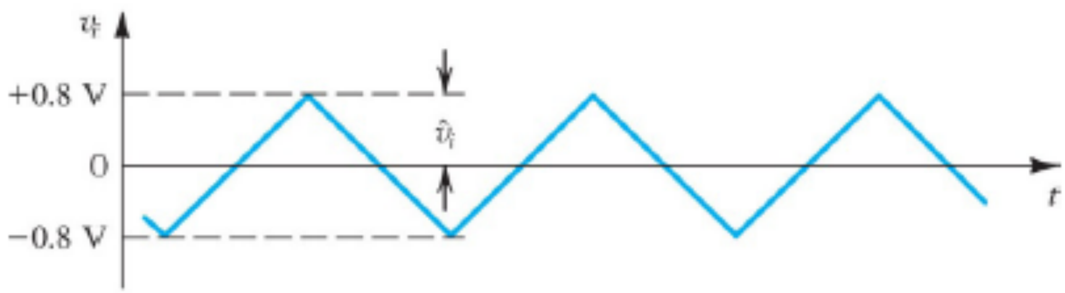


To solve the problem, follow the procedure recommended in Table 7.1.

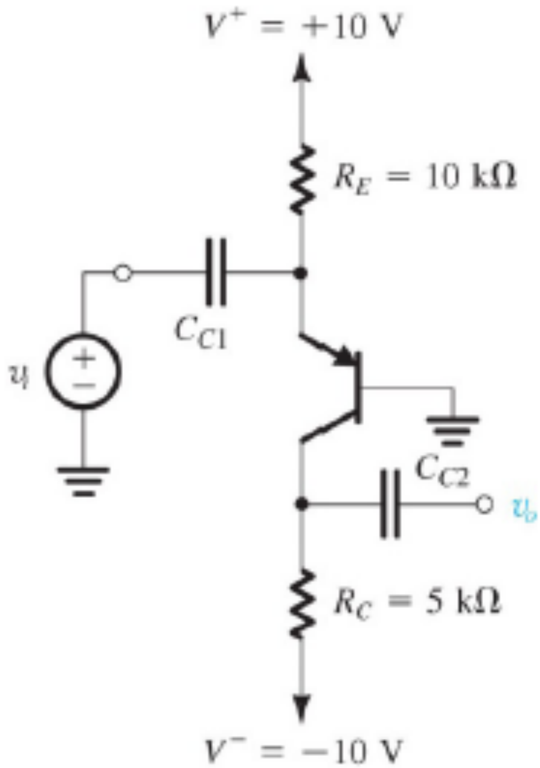
Table 7.1 Systematic Procedure for the Analysis of Transistor Amplifier Circuits
1. Eliminate the signal source and determine the dc operating point of the transistor.
2. Calculate the values of the parameters of the small-signal model.
3. Eliminate the dc sources by replacing each dc voltage source by a short circuit and each dc current source by an open circuit.
4. Replace the transistor with one of its small-signal, equivalent-circuit models. Although any of the models can be used, one might be more convenient than the others for the particular circuit being analyzed. This point will be made clearer in the next section.
5. Analyze the resulting circuit to determine the required quantities (e.g., voltage gain, input resistance).

T_5_2 Analyze the small-signal voltage and current waveforms at the internal nodes of the BJT transistor amplifier from T_5_1. Assume that the input ac signal v_i is a triangular waveform of an amplitude 0.8 V (1.6 V peak-to-peak)





T_5_3 Analyze the BJT transistor amplifier shown below. Determine the voltage gain v_o/v_i, and the signal waveforms at internal nodes of the circuit. Assume $\beta = 100$ and ignore the Early (base-width modulation) effect ($V_A = \infty$). The role of coupling capacitors C_{C1} and C_{C2} is to couple the ac signals at the input and at the output while blocking the dc.



To solve the problem, follow the procedure recommended in Table 7.1.

Table 7.1 Systematic Procedure for the Analysis of Transistor Amplifier Circuits

1. Eliminate the signal source and determine the dc operating point of the transistor.
2. Calculate the values of the parameters of the small-signal model.
3. Eliminate the dc sources by replacing each dc voltage source by a short circuit and each dc current source by an open circuit.
4. Replace the transistor with one of its small-signal, equivalent-circuit models. Although any of the models can be used, one might be more convenient than the others for the particular circuit being analyzed. This point will be made clearer in the next section.
5. Analyze the resulting circuit to determine the required quantities (e.g., voltage gain, input resistance).

T_5_4 The BJT transistor shown below is biased with a constant current source I = 1 mA and has $\beta = 100$ and the Early voltage $V_A = 100$ V.

(a) Neglecting the Early effect, find the dc voltages at the base, collector and emitter.

(b) Find small-signal parameters g_m, r_π, and r_o.

(c) If terminal Z is connected to ground, X to a signal source v_{sig} with a source resistance R_{sig} = 2 kΩ, and Y to a 8-kΩ load resistance, use the hybrid-π BJT model to draw the small-signal equivalent model of the amplifier. Calculate the overall gain v_y/v_{sig}.

(d) If r_o is neglected, what is the error in estimating the gain magnitude?

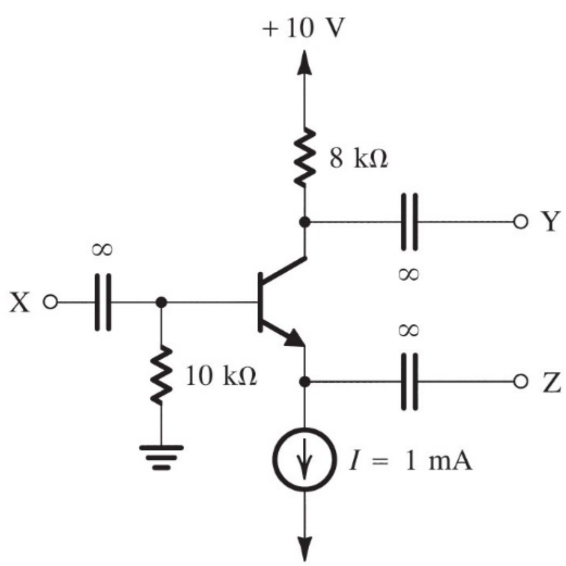
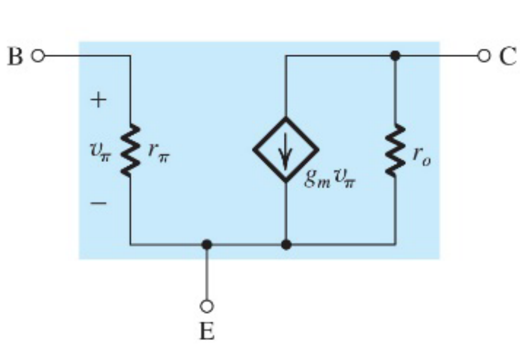


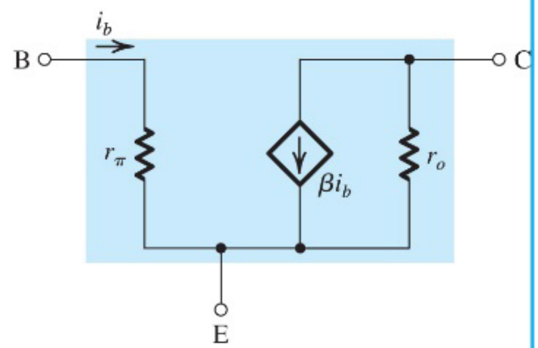
Table 7.3 Small-Signal Models of the BJT

Hybrid-π Model

- $(g_m v_\pi)$ Version

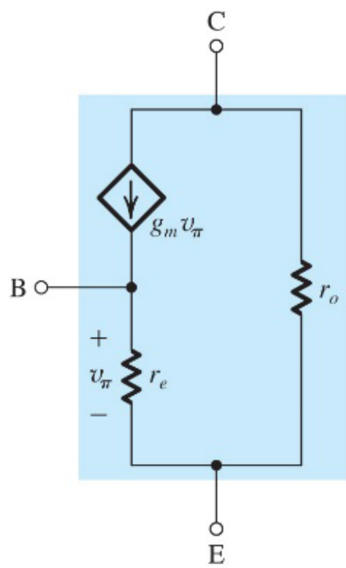


- (βi_b) Version

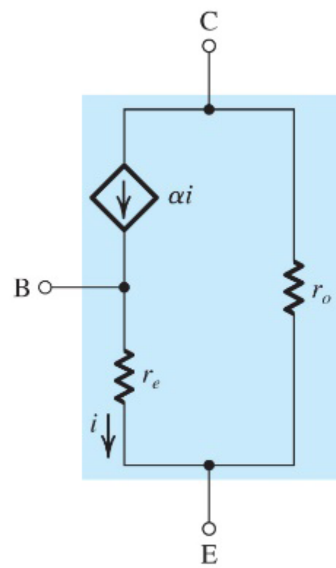


T Model

- $(g_m v_\pi)$ Version



- (αi) Version



Model Parameters in Terms of DC Bias Currents

$$g_m = \frac{I_C}{V_T} \qquad r_e = \frac{V_T}{I_E} = \alpha \frac{V_T}{I_C} \qquad r_\pi = \frac{V_T}{I_B} = \beta \frac{V_T}{I_C} \qquad r_o = \frac{|V_A|}{I_C}$$

In Terms of g_m

$$r_e = \frac{\alpha}{g_m} \qquad r_\pi = \frac{\beta}{g_m}$$

In Terms of r_e

$$g_m = \frac{\alpha}{r_e} \qquad r_\pi = (\beta + 1) r_e \qquad g_m + \frac{1}{r_\pi} = \frac{1}{r_e}$$

Relationships between α and β

$$\beta = \frac{\alpha}{1-\alpha} \qquad \alpha = \frac{\beta}{\beta+1} \qquad \beta + 1 = \frac{1}{1-\alpha}$$