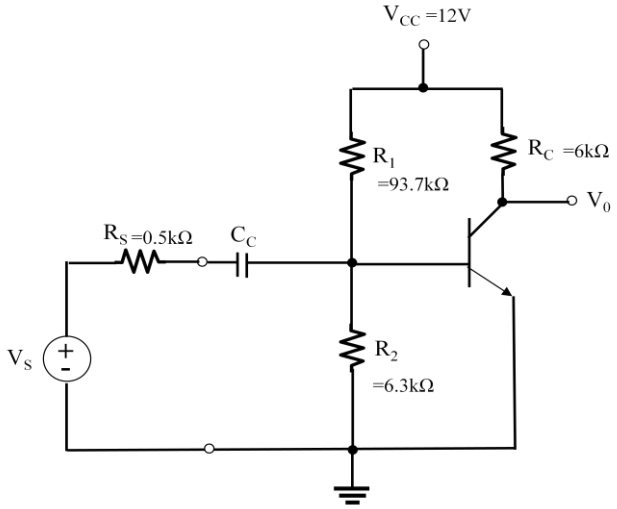
Chapter 6

基本雙極電晶體放大電路

6.4 共射級放大器

6.4 共射極放大器

◆ 基本共射極放大器電路



步驟一:DC 分析

(1)假設 Q 工作在 FAR

(2)計算

$$V_{TH} = 12 \times \frac{6.3k}{93.7k + 6.3k} = 0.756V$$

$$R_{TH} = 93.7k \parallel 6.3k$$

$$I_B = \frac{0.756 - 0.7}{5.9k} = 9.49\mu A$$

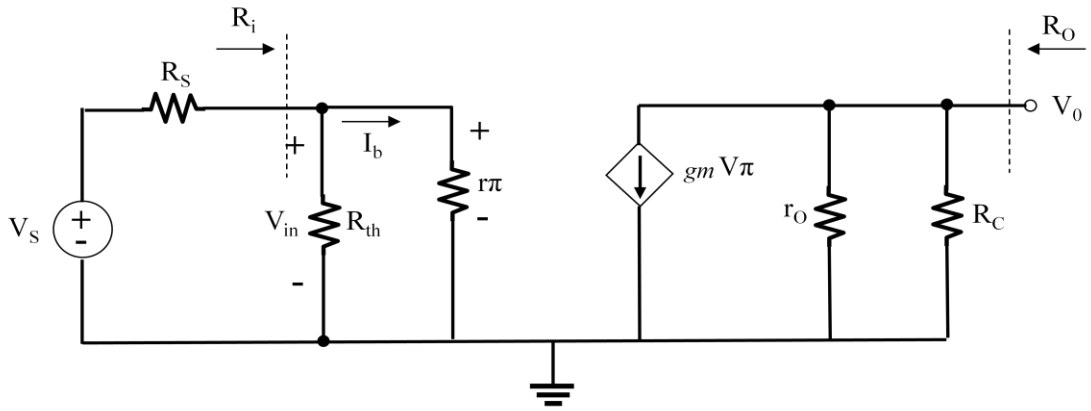
$$I_C = 0.949mA$$

$$I_E = 0.95849mA$$

$$V_{CE} = 6.306V$$

步驟二:AC 分析

(1)重畫等效電路



(2)計算參數

$$r_\pi = \frac{V_T}{I_{BQ}} = 2.739\text{k}\Omega$$

$$r_o = \frac{V_A}{I_{CQ}} = 105.374\text{k}\Omega$$

$$g_m = \frac{I_{CQ}}{V_T} = 36.5\,{}^{\text{mA}}\!/_{\text{V}}$$

(3)求A_V、R_{in}、R_{out}

$$V_\pi = V_S \times \frac{R_{TH} \parallel r_\pi}{R_{TH} \parallel r_\pi + R_S}$$

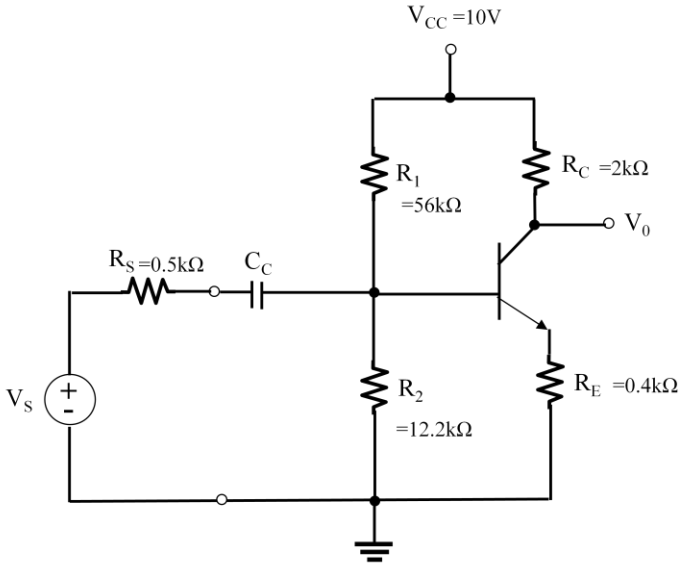
$$V_O = -g_m V_\pi (R_C \parallel r_O)$$

$$A_V = \frac{V_O}{V_S} = -g_m \frac{R_{TH} \parallel r_\pi}{R_{TH} \parallel r_\pi + R_S}(R_C \parallel r_O) = -163.5$$

$$R_{in} = R_{TH} \parallel r_\pi = 1.871\text{k}\Omega$$

$$R_{out} = R_C \parallel r_O = 5.6768\text{k}\Omega$$

◆ 含有射極電阻的電路



步驟一:DC 分析

(1)假設 Q 工作在 FAR

(2)計算

$$V_{TH} = 10 \times \frac{12.2k}{56k + 12.2k} = 1.79V$$

$$R_{TH} = 56k \parallel 12.2k = 10.018k\Omega$$

$$I_B = \frac{V_{TH} - V_{BE}}{R_{TH} + (1+\beta)R_E} = 21.619\mu A$$

$$I_C = 2.619mA$$

$$I_E = 2.1835mA$$

$$V_{CE} = V_{CC} - I_C R_C - I_E R_E = 4.803V$$

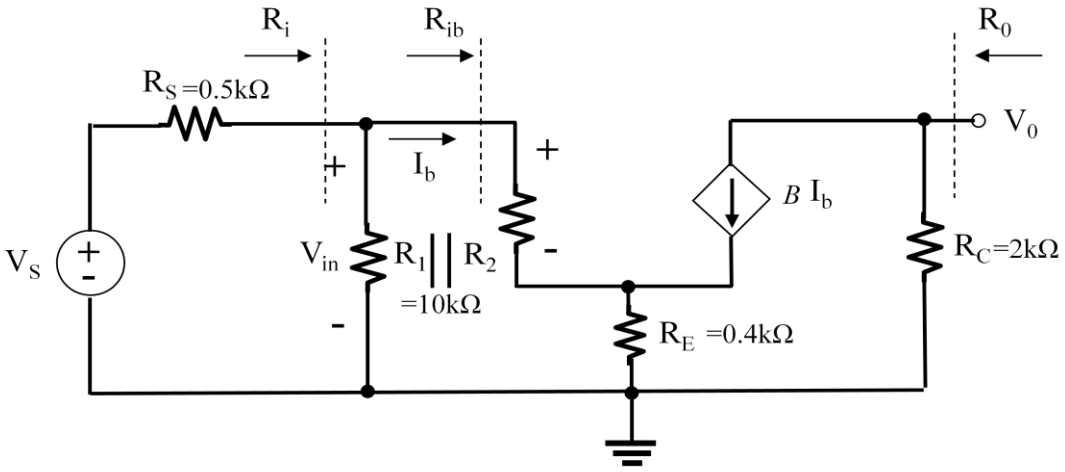
(3)驗證

$$I_B = 21.619\mu A > 0$$

$$V_{CE} = 4.803V > 0.2V$$

步驟二:AC 分析

(1)重畫等效電路



(2)計算參數

$$r_\pi = \frac{V_T}{I_{BQ}} = 1.203k\Omega$$

$$r_o = \frac{V_A}{I_{CQ}} = \infty$$

$$g_m = \frac{I_{CQ}}{V_T} = 83.15\,{}^{mA}/_{V}$$

(3)求A_V、R_{in}、R_{out}

$$V_O = -\beta i_b R_C$$

$$V_B = V_S \times \frac{R_{TH} \parallel R_{ib}}{R_{TH} \parallel R_{ib} + R_S}$$

$$i_b = \frac{V_B}{R_{ib}} = \frac{V_S}{R_{ib}} \frac{R_{TH} \parallel R_{ib}}{R_{TH} \parallel R_{ib} + R_S}$$

$$A_V = \frac{V_O}{V_S} = -\beta \frac{R_C}{R_{ib}} \frac{R_{TH} \parallel R_{ib}}{R_{TH} \parallel R_{ib} + R_S}$$

將 $R_{ib} = r_\pi + (1+\beta)R_E$代入上式

$$A_V = \frac{V_O}{V_S} = -\beta \frac{R_C}{R_{ib}} \frac{R_{TH} \parallel (r_\pi + (1+\beta)R_E)}{R_{TH} \parallel (r_\pi + (1+\beta)R_E) + R_S}$$

When $(1+\beta)R_E \gg r_\pi$

$$A_V \cong -\beta \frac{R_C}{(1+\beta)R_E} \frac{\left((1+\beta)R_E\right) \parallel R_{TH}}{\left((1+\beta)R_E\right) \parallel R_{TH} + R_S} = -4.5263$$

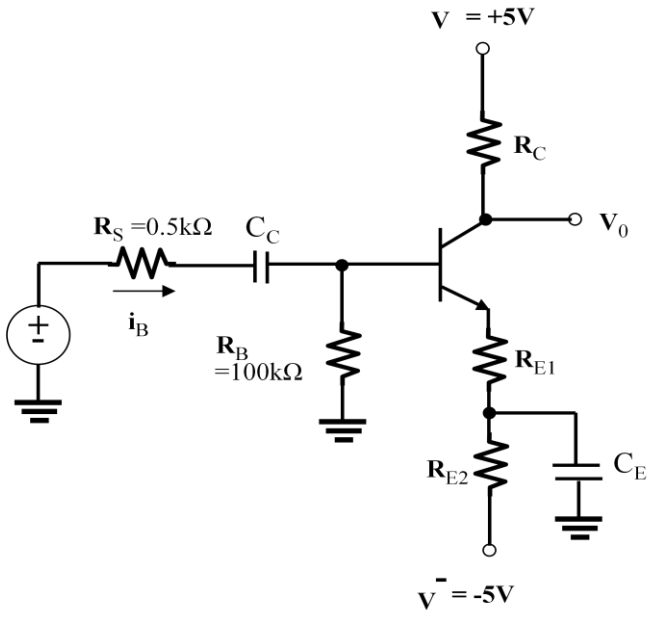
將 $R_{ib} = r_\pi + (1+\beta)R_E = 41.603k\Omega$

$$R_{in} = R_{TH} \parallel R_{ib} = 8.06k\Omega$$

$$R_{out} = R_C = 2k\Omega$$

◆ 加入射極電阻後，可提升電壓增益的穩定性也可降低負載效應。

◆ 加入射極旁路電容之電路



步驟一:DC 分析

(1)假設 Q 工作在 FAR

(2)計算

$$I_B = \frac{0 - V_{BE(ON)} - (-5)}{R_B + (1+\beta)(R_{E1} + R_{E1})}$$

$$I_C = \beta I_B$$

$$I_E = (1+\beta) I_B$$

$$V_{CE} = V_{CC} - I_C R_C - I_E(R_{E1} + R_{E1})$$

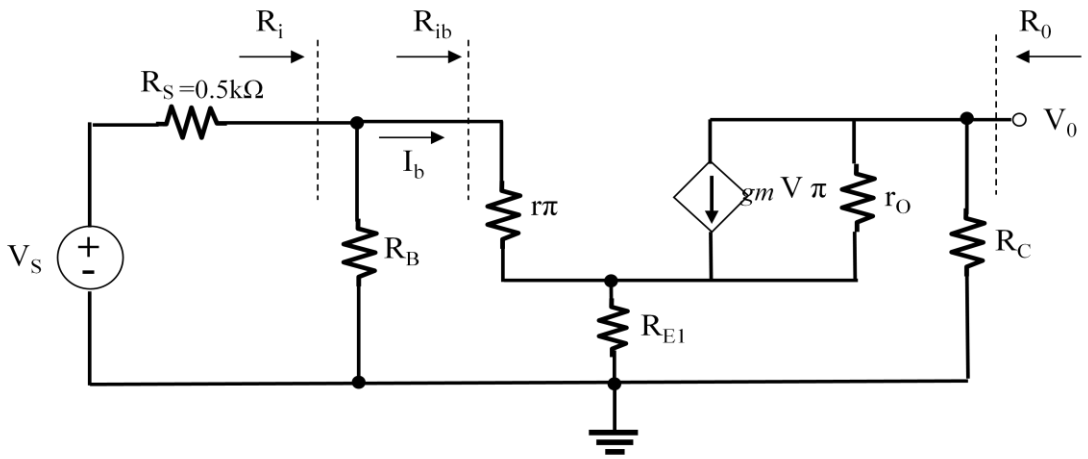
(3)驗證

$$I_B > 0$$

$$V_{CE} > 0.2V$$

步驟二:AC 分析

(1)重畫等效電路



(2)計算參數

$$r_\pi = \frac{V_T}{I_{BQ}}$$

$$r_o = \frac{V_A}{I_{CQ}}$$

$$g_m = \frac{I_{CQ}}{V_T}$$

(3)求A_V、R_{in}、R_{out}

$$R_{ib} = r_\pi + (1+\beta)R_{E1}$$

$$V_O = -\beta i_b R_C$$

$$\because r_o \to \infty$$

$$i_b = \frac{V_S}{R_{ib}} \frac{R_B \parallel R_{ib}}{R_B \parallel R_{ib} + R_S}$$

$$R_{in} = R_B \parallel R_{ib}$$

$$R_{out} = R_C$$