Chapter 7. 頻率響應
(Frequency Response)

7.3 頻率響應:具有電路電容的電晶體放大器

南台科技大學
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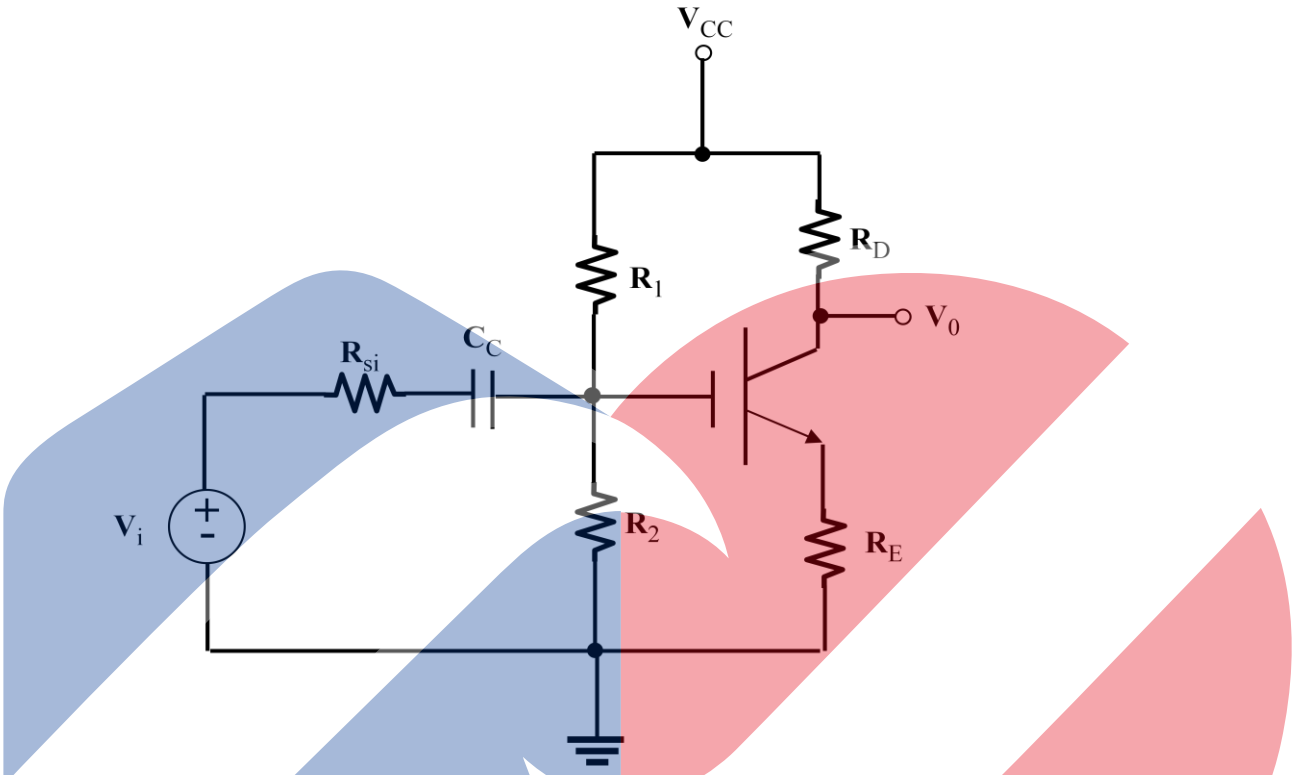
1. 耦合電容效應

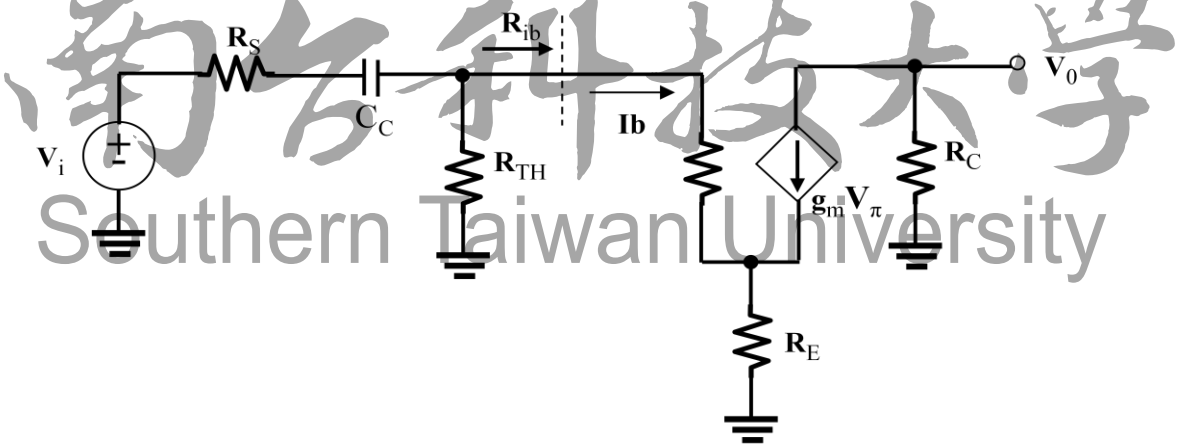


步驟(一)DC 分析

1. 假設
2. 計算
3. 驗證

步驟(二)AC 分析

1. 畫等效電路圖



2. 參數計算

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

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

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

3. 計算

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

$$V_{ib} = \frac{R_{TH} \parallel R_{ib}}{R_{si} + \frac{1}{SC_C} + (R_{TH} \parallel R_{ib})} V_i$$

$$I_b = \frac{V_{ib}}{R_{ib}}$$

$$V_o = -\beta I_b R_C$$

$$= -\beta \frac{R_{TH} \parallel R_{ib}}{R_{si} + \frac{1}{SC_C} + (R_{TH} \parallel R_{ib})} V_i R_C \frac{1}{R_{ib}}$$

$$\frac{V_o}{V_i} = -\beta \frac{R_{TH} \parallel R_{ib}}{R_{si} + \frac{1}{SC_C} + (R_{TH} \parallel R_{ib})} R_C \frac{1}{R_{ib}}$$

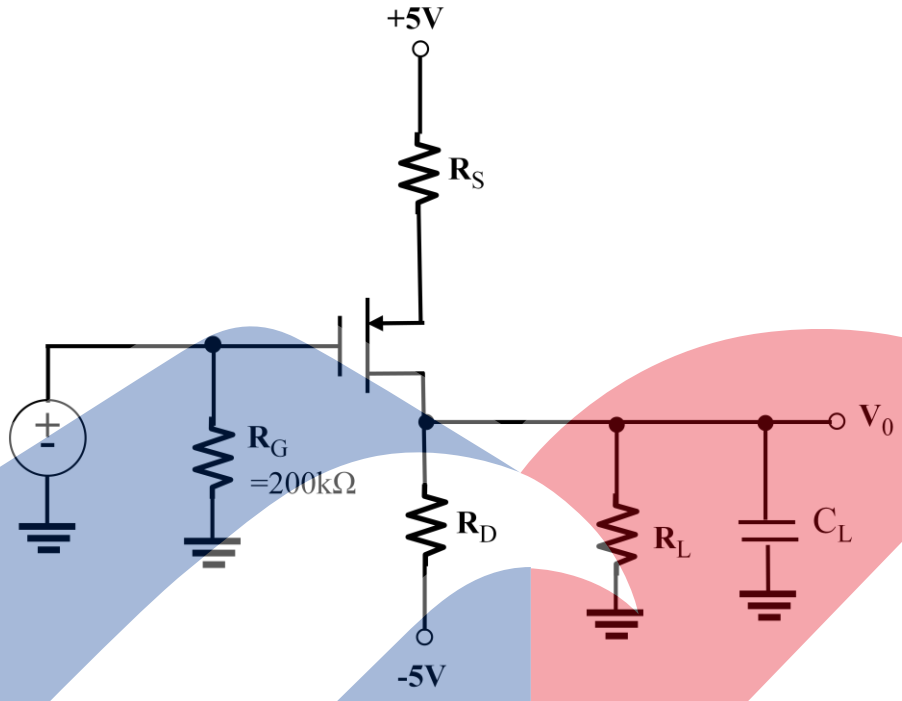
$$= -\beta \frac{R_C}{R_{ib}} \frac{R_{TH} \parallel R_{ib}}{R_{si} + (R_{TH} \parallel R_{ib})} \frac{R_{si} + (R_{TH} \parallel R_{ib})SC_C}{1 + [R_{si} + (R_{TH} \parallel R_{ib})]SC_C}$$

$$= -\beta \frac{R_C}{R_{ib}} \frac{R_{TH} \parallel R_{ib}}{R_{si} + (R_{TH} \parallel R_{ib})} \frac{s\tau_C}{1 + s\tau_C}$$

$$\tau_C = C_C[R_{si} + (R_{TH} \parallel R_{ib})]$$

$$f_L = f_{3dB} = \frac{1}{2\pi\tau_C}$$

2. 負載電容效應



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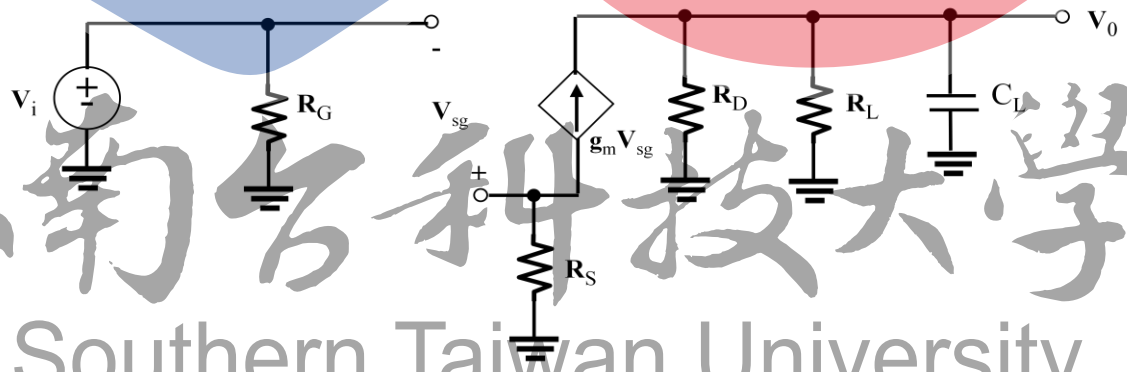


2. 參數計算

$g_m = 2\sqrt{k_n I_D}$

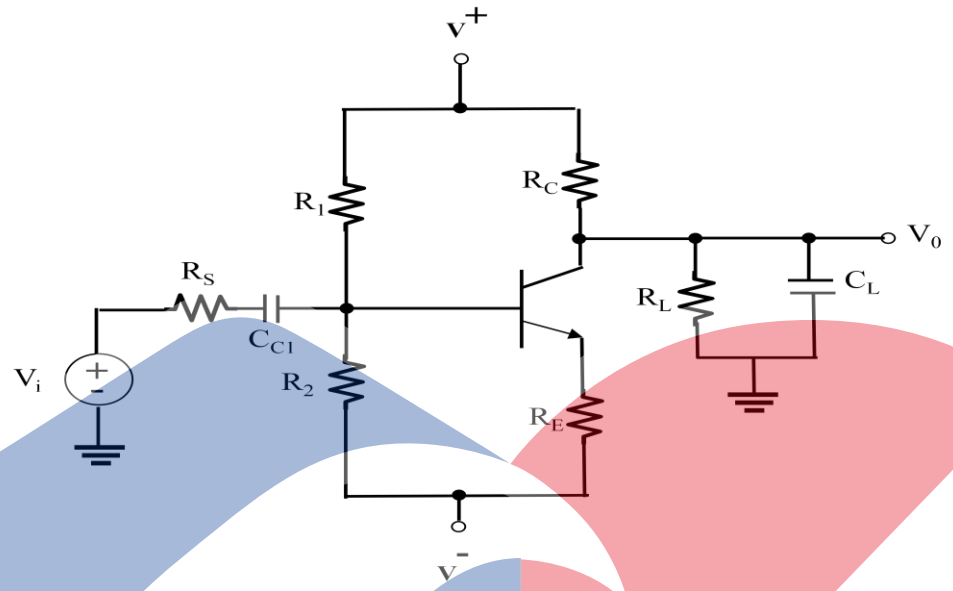
$r_o = (\lambda I_D)^{-1}$

3. 利用時間常數法求$A_V = -g_m(R_D \parallel R_L)$

$$求 f_{3dB} = \frac{1}{2\pi\tau}$$

$$\tau = (R_D \parallel R_L)C_L$$

3. 耦合與負載電容效應



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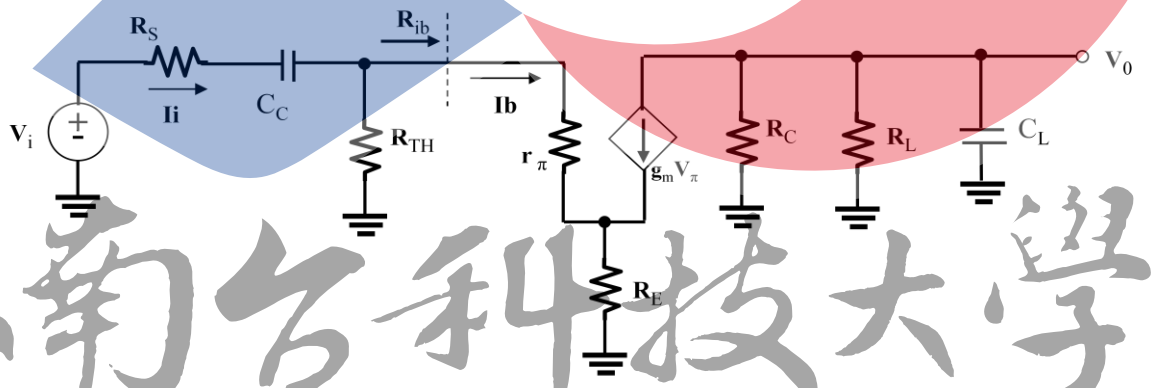


2. 參數計算

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

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

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

3. 利用時間常數法

考慮 C_C $C_C \rightarrow$ SHORT

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

$$\tau = C_C[R_{si} + (R_{TH} \parallel R_{ib})]$$

$$f_{3dBH} = \frac{1}{2\pi C_C[R_{si} + (R_{TH} \parallel R_{ib})]}$$

考慮 C_L $C_C \rightarrow$ SHORT

$$\tau = C_L(R_C \parallel R_L)$$

$$f_{3dBL} = \frac{1}{2\pi C_L(R_C \parallel R_L)}$$

求A_V

$C_C \rightarrow$ SHORT，$C_C \rightarrow$ SHORT

$$I_b = \frac{V_{ib}}{R_{ib}}$$

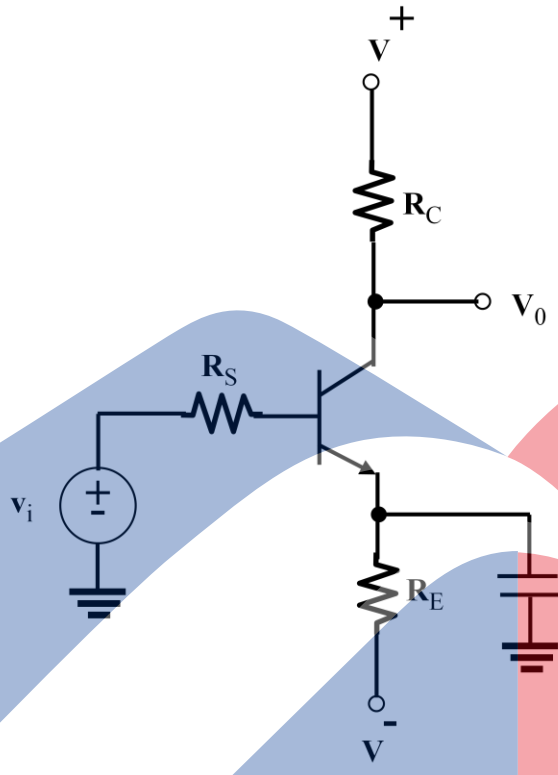
$$V_{ib} = \frac{R_{TH} \parallel R_{ib}}{R_s + (R_{TH} \parallel R_{ib})} V_i$$

$$V_o = -\beta I_b(R_C \parallel R_L)$$

$$= -\beta(R_C \parallel R_L)\frac{R_{TH} \parallel R_{ib}}{R_s + (R_{TH} \parallel R_{ib})}\frac{V_i}{R_{ib}}$$

$$A_V = \frac{V_o}{V_i} = -\beta(R_C \parallel R_L)\frac{1}{R_s + (R_{TH} \parallel R_{ib})}\frac{R_{TH}}{R_{ib} + R_{TH}}$$

4. 旁路電容效應



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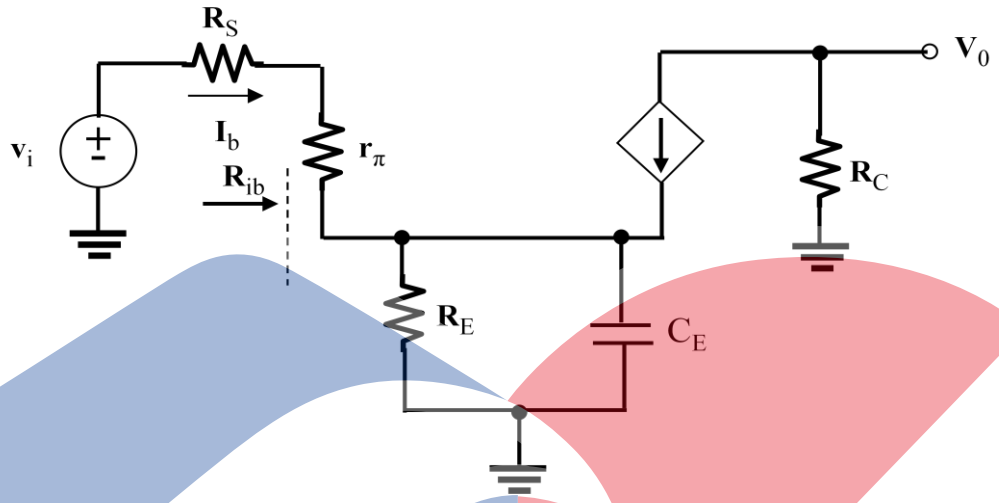

2. 參數計算

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

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

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

3. 計算

$$R_{ib} = r_\pi + (1+\beta)(R_E \parallel \frac{1}{SC_E})$$

$$I_b = \frac{V_i}{R_{ib} + R_S}$$

$$V_o = -\beta I_b R_C$$

$$= -\beta \frac{V_i R_C}{R_s + r_\pi + (1+\beta)(R_E \parallel \frac{1}{SC_E})}$$

$$A_V = \frac{V_o}{V_i} = -\beta R_C \frac{1}{\frac{R_E \times \frac{1}{SC_E}}{R_s + r_\pi + (1+\beta)(\frac{R_E + \frac{1}{SC_E}}{})}}$$

$$= -\beta R_C \frac{1}{R_s + r_\pi + (1+\beta)} (\frac{1 + R_E SC_E}{1 + \frac{(R_s + r_\pi) R_E SC_E}{R_s + r_\pi + (1+\beta) R_E}})$$

$$= -\beta R_C \frac{1}{R_s + r_\pi + (1+\beta)} \frac{1 + s\tau_A}{1 + s\tau_B}$$

$\tau_A = R_E C_E$

$\tau_B = \frac{(R_s + r_\pi) R_E C_E}{R_s + r_\pi + (1+\beta) R_E}$

When $1 + s\tau_A = 0$

$$f_A = \frac{1}{2\pi\tau_A} \text{(零點)}$$

When $1 + s\tau_B = 0$

$$f_A = \frac{1}{2\pi\tau_B} \text{(極點)}$$

When f→0

$$A_V = \beta R_C \frac{1}{R_s + r_\pi + (1+\beta)}$$

When f→0

$$A_V = \frac{\beta R_C}{R_s + r_\pi}$$