



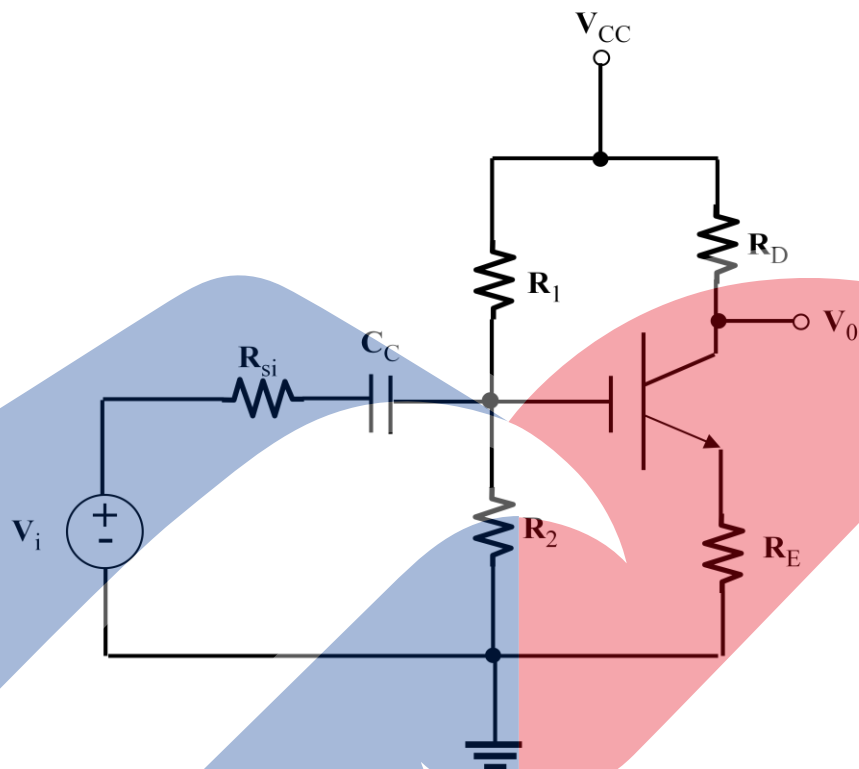
# Chapter 7. 頻率響應 (Frequency Response)

7.3 頻率響應:具有電路電容的電晶體放大器

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### 7.3 頻率響應:具有電路電容的電晶體放大器

#### 1. 耦合電容效應

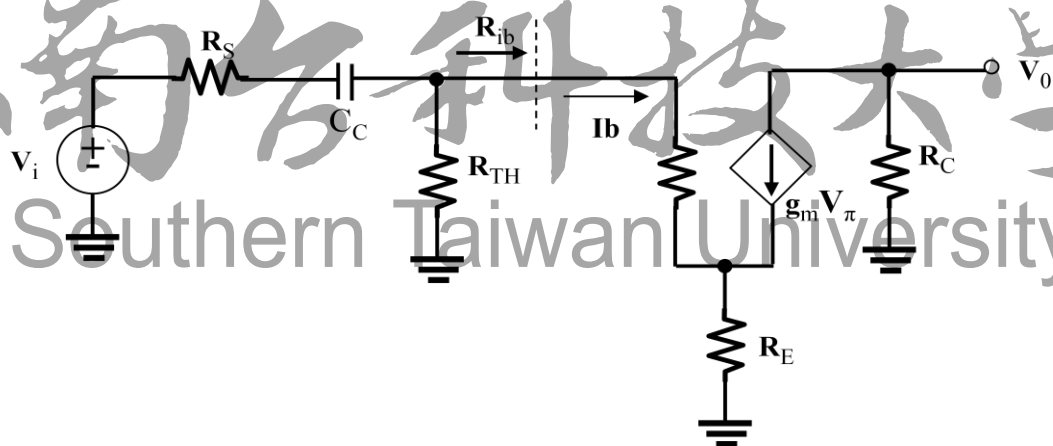


#### 步驟(一)DC 分析

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

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

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

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

$$V_o = -\beta I_b R_C$$

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

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

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

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

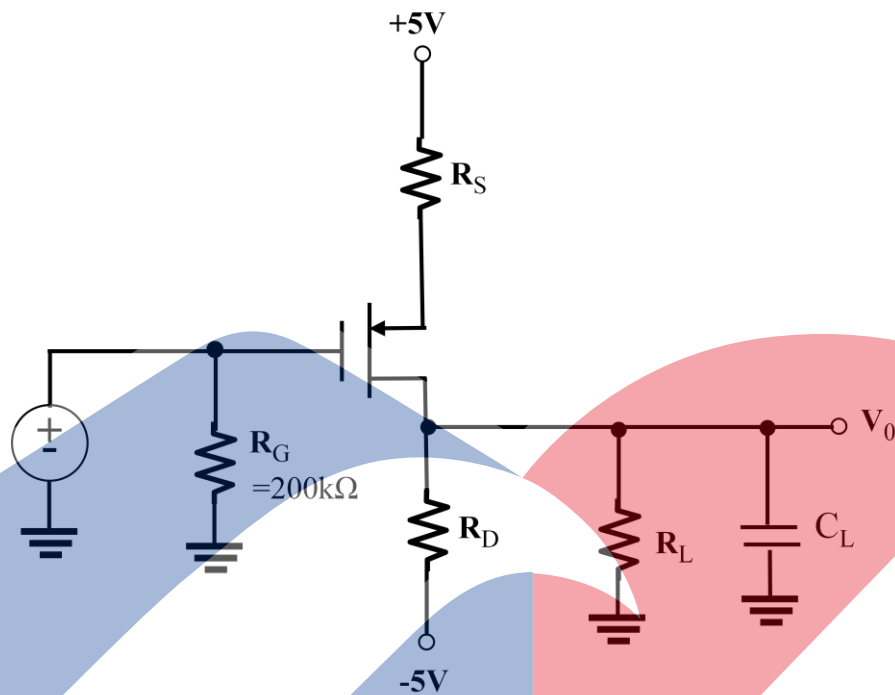
$$\tau_C = C_C [R_{si} + (R_{TH} \parallel R_{ib})]$$

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

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## 2. 負載電容效應

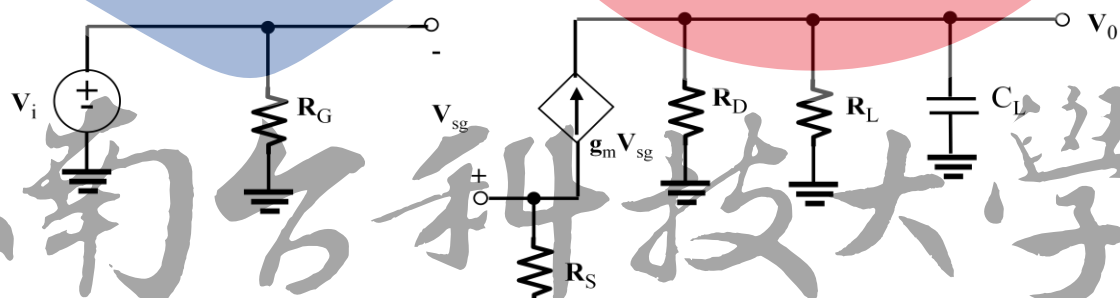


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### 步驟(二)AC 分析

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2. 參數計算

$$g_m = 2\sqrt{k_n I_D}$$

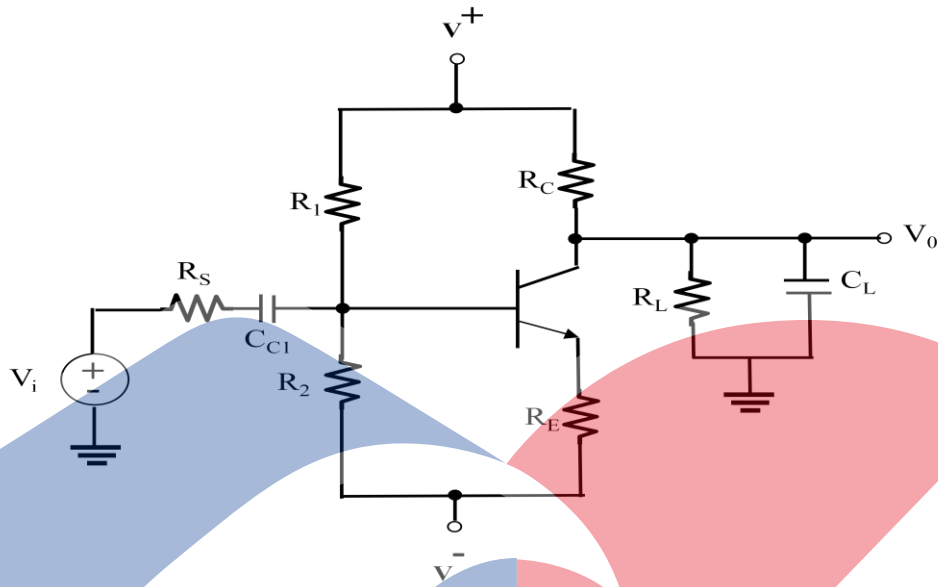
$$r_o = (\lambda I_D)^{-1}$$

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

$$\text{求 } f_{3\text{dB}} = \frac{1}{2\pi\tau}$$

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

### 3. 耦合與負載電容效應

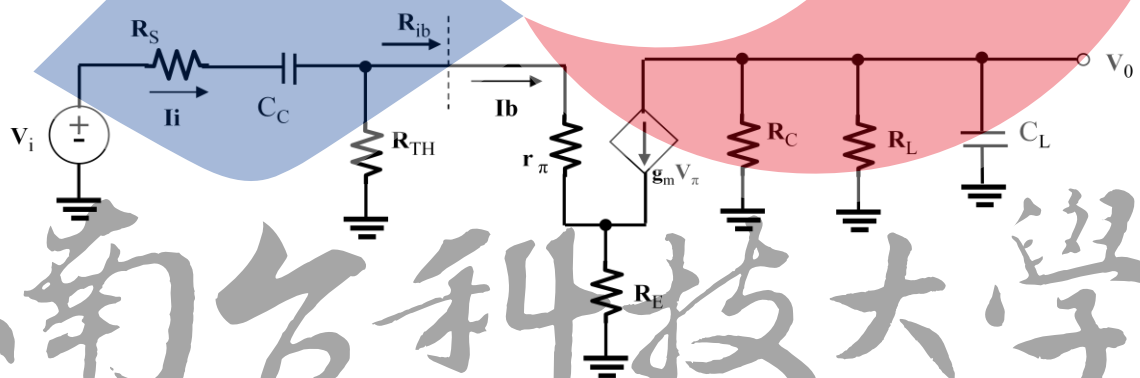


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1. 畫等效電路圖



#### 2. 參數計算

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

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

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

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3. 利用時間常數法

考慮  $C_C$   $C_C \rightarrow \text{SHORT}$

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

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

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

考慮  $C_L$   $C_C \rightarrow \text{SHORT}$

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

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

求  $A_V$

$C_C \rightarrow \text{SHORT}$ ,  $C_C \rightarrow \text{SHORT}$

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

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

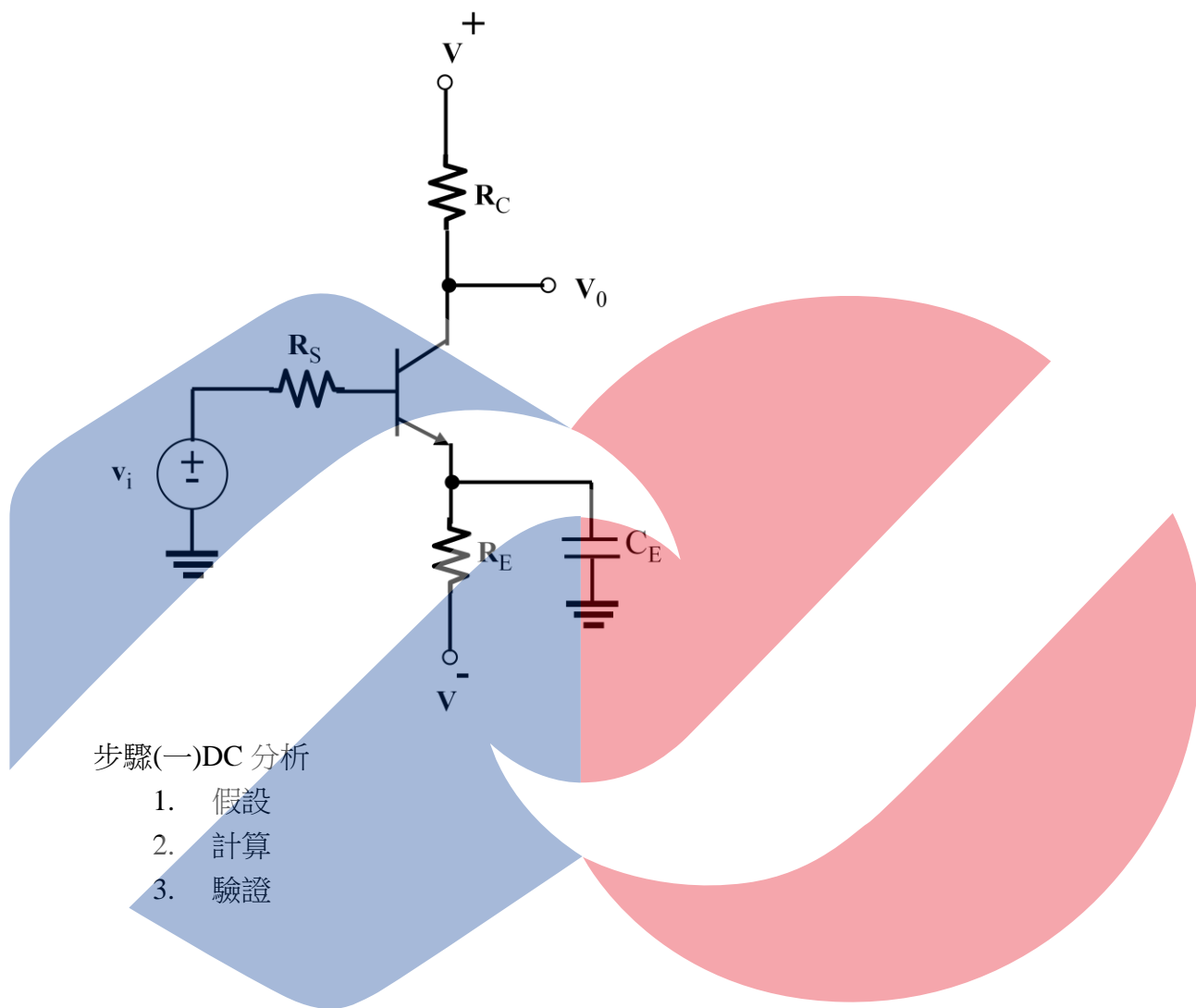
$$V_o = -\beta I_b (R_C \parallel R_L)$$

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

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

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#### 4. 旁路電容效應



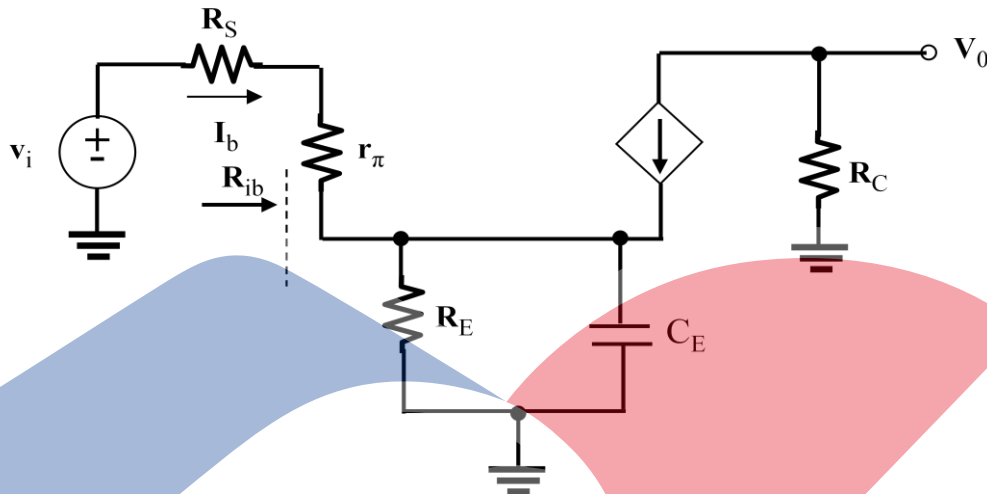
步驟(一)DC 分析

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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

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

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

$$V_o = -\beta I_b R_C = -\beta \frac{V_i R_C}{R_S + r_\pi + (1 + \beta)(R_E \parallel \frac{1}{sC_E})}$$

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

$$= -\beta R_C \frac{1}{R_S + r_\pi + (1 + \beta)} \left( \frac{1 + R_E s C_E}{1 + \frac{(R_S + r_\pi) R_E s C_E}{R_S + r_\pi + (1 + \beta) R_E}} \right)$$

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

$$\tau_A = R_E C_E$$

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

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  $f \rightarrow 0$

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

When  $f \rightarrow \infty$

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

The logo of Southern Taiwan University is a stylized circular emblem. It is divided into four quadrants by a white diagonal line from the top-left to the bottom-right. The top-right and bottom-left quadrants are colored red, while the top-left and bottom-right quadrants are colored blue. The emblem is positioned behind the university's name.

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