

**Chapter 4. 基本場效電晶體
(FET)放大器(Basic FET
Amplifiers)**

4.6 單級積體 MOSFET 放大器

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4.6 單級積體 MOSFET 放大器

1. 具增強型負載的 NMOS 放大器

AC 分析

A. 畫出等效電路圖

B. 參數計算

$$g_{mL} = 2\sqrt{k_{nL}I_{DQ}}, r_{oL} = (\lambda I_{DQ})^{-1}$$

$$g_{mD} = 2\sqrt{k_{nD}I_{DQ}}, r_{oD} = (\lambda I_{DQ})^{-1}$$

C. 求 A_V 、 R_{in} 、 R_{out}

$$V_{gsL} = -v_o, V_{gsD} = v_i$$

$$i_{roD} = \frac{v_o}{r_{oD}}, i_{roL} = \frac{v_o}{r_{oL}}$$

A 點 KCL: $g_{mD}V_{gsD} + i_{roD} + i_{roL} - g_{mL}V_{gsL} = 0$

$$\rightarrow \rightarrow g_{mD}v_i + \frac{v_o}{r_{oD}} + g_{mL}v_o + \frac{v_o}{r_{oL}} = 0$$

$$\rightarrow \rightarrow v_o \left(\frac{1}{r_{oD}} + g_{mL} + \frac{1}{r_{oL}} \right) = -g_{mD}v_i$$

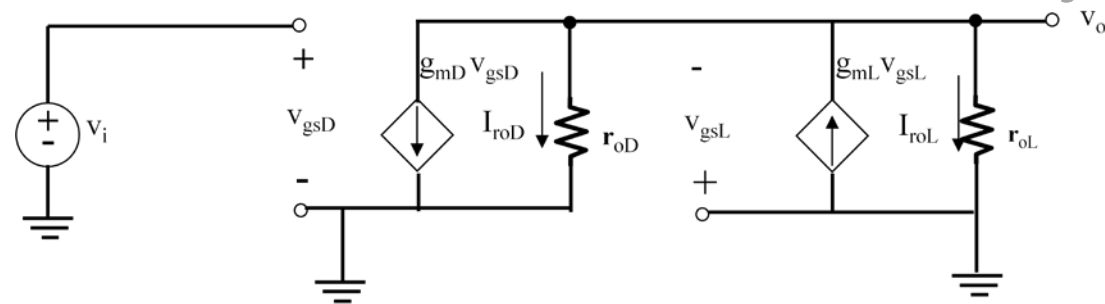
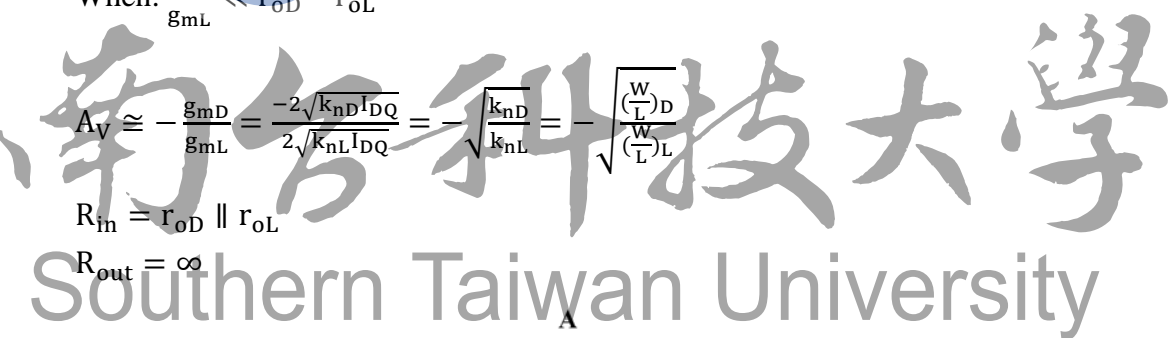
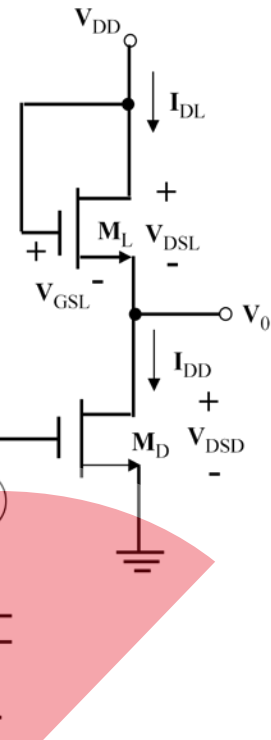
$$A_V = \frac{v_o}{v_i} = \frac{-g_{mD}}{\left(\frac{1}{r_{oD}} + g_{mL} + \frac{1}{r_{oL}} \right)} = \frac{-g_{mD}}{\left(\frac{1}{r_{oD}} + \frac{1}{\frac{1}{g_{mL}}} + \frac{1}{r_{oL}} \right)} = -g_{mD} (r_{oD} \parallel \frac{1}{g_{mL}} \parallel r_{oL})$$

When: $\frac{1}{g_{mL}} \ll r_{oD}, r_{oL}$

$$A_V \cong -\frac{g_{mD}}{g_{mL}} = \frac{-2\sqrt{k_{nD}I_{DQ}}}{2\sqrt{k_{nL}I_{DQ}}} = -\sqrt{\frac{k_{nD}}{k_{nL}}} = -\sqrt{\frac{(W/L)_D}{(W/L)_L}}$$

$$R_{in} = r_{oD} \parallel r_{oL}$$

$$R_{out} = \infty$$



2. 具空乏型負載的 NMOS 放大器

AC 分析

A. 畫出等效電路圖

B. 參數計算

$$g_{mL} = 2\sqrt{k_{nL}I_{DQ}} \cdot r_{oL} = (\lambda I_{DQ})^{-1}$$

$$g_{mD} = 2\sqrt{k_{nD}I_{DQ}} \cdot r_{oD} = (\lambda I_{DQ})^{-1}$$

C. 求 A_V 、 R_{in} 、 R_{out}

$$V_{gsL} = -v_o \cdot V_{gsD} = v_i$$

$$i_{roD} = \frac{v_o}{r_{oD}} \cdot i_{roL} = \frac{v_o}{r_{oL}}$$

$$g_{mL}V_{gsL} = 0$$

A 點 KCL: $g_{mD}V_{gsD} + i_{roD} + i_{roL} = 0$

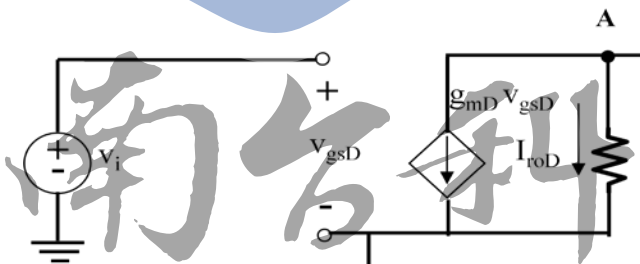
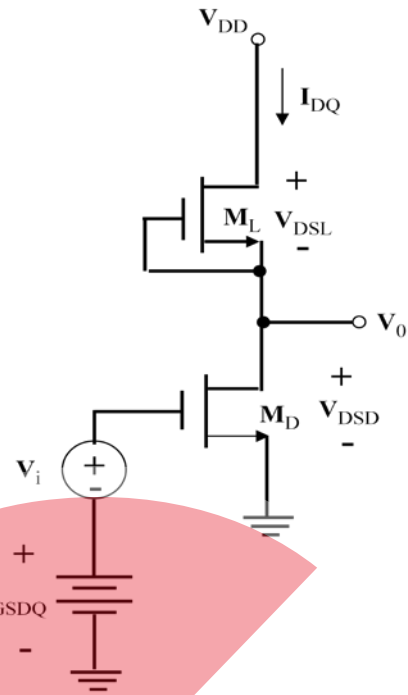
$$\rightarrow g_{mD}v_i + \frac{v_o}{r_{oD}} + \frac{v_o}{r_{oL}} = 0$$

$$\rightarrow v_o \left(\frac{1}{r_{oD}} + \frac{1}{r_{oL}} \right) = -g_{mD}v_i$$

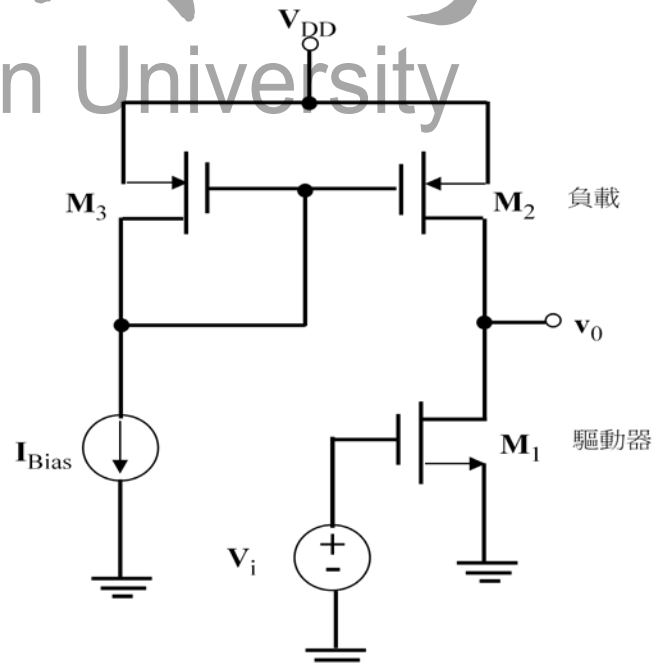
$$A_V = \frac{v_o}{v_i} = \frac{-g_{mD}}{\left(\frac{1}{r_{oD}} + \frac{1}{r_{oL}} \right)} = -g_{mD}(r_{oD} \parallel r_{oL})$$

$$R_{in} = r_{oD} \parallel r_{oL}$$

$$R_{out} = \infty$$



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3. 具主動負載的 NMOS 放大器

AC 分析

D. 畫出等效電路圖

E. 參數計算

$$g_{mL} = 2\sqrt{k_{nL}I_{DQ}} \cdot r_{oL} = (\lambda I_{DQ})^{-1}$$

$$g_{mD} = 2\sqrt{k_{nD}I_{DQ}} \cdot r_{oD} = (\lambda I_{DQ})^{-1}$$

F. 求 A_V 、 R_{in} 、 R_{out}

$$v_{sgL} = v_O \cdot v_{gsD} = v_i$$

$$i_{roD} = \frac{v_O}{r_{oD}} \cdot i_{roL} = \frac{v_O}{r_{oL}}$$

$$g_{mL}v_{sgL} = 0$$

A 點 KCL: $g_{mD}v_{gsD} + i_{roD} + i_{roL} = 0$

$$\rightarrow \rightarrow g_{mD}v_i + \frac{v_O}{r_{oD}} + \frac{v_O}{r_{oL}} = 0$$

$$\rightarrow \rightarrow v_O \left(\frac{1}{r_{oD}} + \frac{1}{r_{oL}} \right) = -g_{mD}v_i$$

$$A_V = \frac{v_O}{v_i} = \frac{-g_{mD}}{\left(\frac{1}{r_{oD}} + \frac{1}{r_{oL}} \right)} = -g_{mD}(r_{oD} \parallel r_{oL})$$

$$R_{in} = r_{oD} \parallel r_{oL}$$

$$R_{out} = \infty$$

