

Question:

For a MOSFET current source circuit in **Figure 1** the transistor parameters are $V_{TN} = 0.5 \text{ V}$, $\lambda = 0$, and $k'_n = 80 \mu\text{A}/\text{V}^2$. **Design** the circuit such that $V_{DS2}(\text{sat}) = 0.3 \text{ V}$, $I_{REF} = 50 \mu\text{A}$, and the load current is $I_O = 100 \mu\text{A}$. Show clearly all calculations as marks are given according to this.

[10 marks]

Answer:

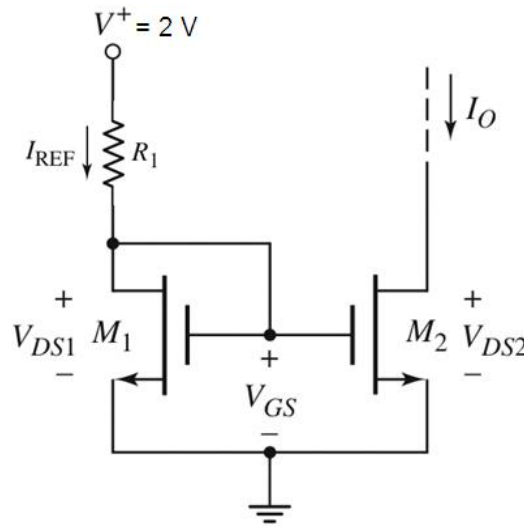


Figure 1

$$V_{DS2}(\text{sat}) = V_{GS} - V_{TN} \quad [1]$$

$$V_{GS} = V_{DS2}(\text{sat}) + V_{TN} = 0.3 + 0.5 = 0.8 \text{ V} \quad [1]$$

$$I_{REF} = (V^+ - V_{GS} - 0) / R_1 \quad [1]$$

$$R_1 = (V^+ - V_{GS} - 0) / I_{REF} = (2 - 0.8) / (50\mu) = 24 \text{ k}\Omega \quad [1]$$

$$I_{REF} = (k'_n / 2) (W/L)_1 [V_{GS} - V_{TN}]^2 \quad [1]$$

$$(W/L)_1 = I_{REF} / \{(k'_n / 2) [V_{GS} - V_{TN}]^2\} \quad [1]$$

$$= (50\mu) / \{(80\mu/2) [0.8 - 0.5]^2\} \quad [1]$$

$$= 13.889 \quad [1]$$

$$I_O = (k'_n / 2) (W/L)_2 [V_{GS} - V_{TN}]^2 \quad [1]$$

$$(W/L)_2 = I_O / \{(k'_n / 2) [V_{GS} - V_{TN}]^2\} \quad [1]$$

$$= (100\mu) / \{(80\mu/2) [0.8 - 0.5]^2\} \quad [1]$$

$$= 27.778 \quad [1]$$

; N – MOSFET

$$v_{DS}(\text{sat}) = v_{GS} - V_{TN}$$

$$i_D = K_n [v_{GS} - V_{TN}]^2$$

$$K_n = \frac{k'_n}{2} \cdot \frac{W}{L}$$

; P – MOSFET

$$v_{SD}(\text{sat}) = v_{SG} + V_{TP}$$

$$i_D = K_p [v_{SG} + V_{TP}]^2$$

$$K_p = \frac{k'_p}{2} \cdot \frac{W}{L}$$

; Small signal

$$g_m = 2\sqrt{K_n I_{DQ}}$$

$$r_o \cong \frac{1}{\lambda I_{DQ}}$$

Question:

For a MOSFET current source circuit in **Figure 1** the transistor parameters are $V_{TN} = 0.5 \text{ V}$, $\lambda = 0$, and $k'_n = 100 \mu\text{A/V}^2$. **Design** the circuit such that $V_{DS2}(\text{sat}) = 0.3 \text{ V}$, $I_{REF} = 50 \mu\text{A}$, and the load current is $I_O = 80 \mu\text{A}$. Show clearly all calculations as marks are given according to this.

[10 marks]

Answer:

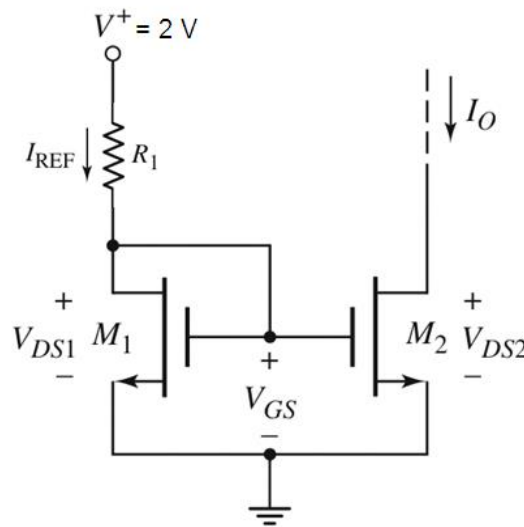


Figure 1

$$V_{DS2}(\text{sat}) = V_{GS} - V_{TN} \quad [1]$$

$$V_{GS} = V_{DS2}(\text{sat}) + V_{TN} = 0.3 + 0.5 = 0.8 \text{ V} \quad [1]$$

$$I_{REF} = (V^+ - V_{GS} - 0) / R_1 \quad [1]$$

$$R_1 = (V^+ - V_{GS} - 0) / I_{REF} = (2 - 0.8) / (50\mu) = 24 \text{ k}\Omega \quad [1]$$

$$I_{REF} = (k'_n / 2) (W/L)_1 [V_{GS} - V_{TN}]^2 \quad [1]$$

$$(W/L)_1 = I_{REF} / \{(k'_n / 2) [V_{GS} - V_{TN}]^2\} \quad [1]$$

$$= (50\mu) / \{(100\mu/2) [0.8 - 0.5]^2\} = 11.111 \quad [1]$$

$$I_O = (k'_n / 2) (W/L)_2 [V_{GS} - V_{TN}]^2 \quad [1]$$

$$(W/L)_2 = I_O / \{(k'_n / 2) [V_{GS} - V_{TN}]^2\} \quad [1]$$

$$= (80\mu) / \{(100\mu/2) [0.8 - 0.5]^2\} = 17.778 \quad [1]$$

; N – MOSFET

$$v_{DS}(\text{sat}) = v_{GS} - V_{TN}$$

$$i_D = K_n [v_{GS} - V_{TN}]^2$$

$$K_n = \frac{k'_n \cdot W}{2 \cdot L}$$

; P – MOSFET

$$v_{SD}(\text{sat}) = v_{SG} + V_{TP}$$

$$i_D = K_p [v_{SG} + V_{TP}]^2$$

$$K_p = \frac{k'_p \cdot W}{2 \cdot L}$$

; Small signal

$$g_m = 2\sqrt{K_n I_{DQ}}$$

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Question:

For a MOSFET current source circuit in **Figure 1** the transistor parameters are $V_{TN} = 0.5 \text{ V}$, $\lambda = 0$, and $k'_n = 80 \mu\text{A/V}^2$. **Design** the circuit such that $V_{DS2}(\text{sat}) = 0.3 \text{ V}$, $I_{REF} = 100 \mu\text{A}$, and the load current is $I_O = 50 \mu\text{A}$. Show clearly all calculations as marks are given according to this.

[10 marks]

Answer:

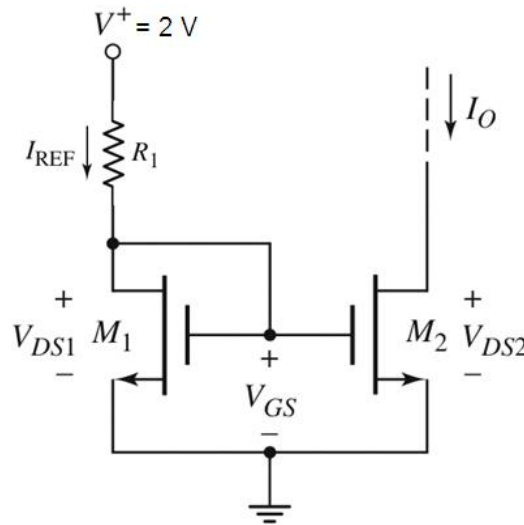


Figure 1

$$V_{DS2}(\text{sat}) = V_{GS} - V_{TN} \quad [1]$$

$$\begin{aligned} V_{GS} &= V_{DS2}(\text{sat}) + V_{TN} \\ &= 0.3 + 0.5 = 0.8 \text{ V} \end{aligned} \quad [1]$$

$$I_{REF} = (V^+ - V_{GS} - 0) / R_1 \quad [1]$$

$$\begin{aligned} R_1 &= (V^+ - V_{GS} - 0) / I_{REF} \\ &= (2 - 0.8) / (100\mu) = 12 \text{ k}\Omega \end{aligned} \quad [1]$$

$$I_{REF} = (k'_n / 2) (W/L)_1 [V_{GS} - V_{TN}]^2 \quad [1]$$

$$\begin{aligned} (W/L)_1 &= I_{REF} / \{(k'_n / 2) [V_{GS} - V_{TN}]^2\} \\ &= (100\mu) / \{(80\mu/2) [0.8 - 0.5]^2\} \\ &= 27.778 \end{aligned} \quad [1]$$

$$I_O = (k'_n / 2) (W/L)_2 [V_{GS} - V_{TN}]^2 \quad [1]$$

$$\begin{aligned} (W/L)_2 &= I_O / \{(k'_n / 2) [V_{GS} - V_{TN}]^2\} \\ &= (50\mu) / \{(80\mu/2) [0.8 - 0.5]^2\} \\ &= 13.889 \end{aligned} \quad [1]$$

; N – MOSFET

$$v_{DS}(\text{sat}) = v_{GS} - V_{TN}$$

$$i_D = K_n [v_{GS} - V_{TN}]^2$$

$$K_n = \frac{k'_n \cdot W}{2 \cdot L}$$

; P – MOSFET

$$v_{SD}(\text{sat}) = v_{SG} + V_{TP}$$

$$i_D = K_p [v_{SG} + V_{TP}]^2$$

$$K_p = \frac{k'_p \cdot W}{2 \cdot L}$$

; Small signal

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For a MOSFET current source circuit in **Figure 1** the transistor parameters are $V_{TN} = 0.5 \text{ V}$, $\lambda = 0$, and $k'_n = 50 \mu\text{A}/\text{V}^2$. **Design** the circuit such that $V_{DS2}(\text{sat}) = 0.3 \text{ V}$, $I_{REF} = 80 \mu\text{A}$, and the load current is $I_O = 100 \mu\text{A}$. Show clearly all calculations as marks are given according to this.

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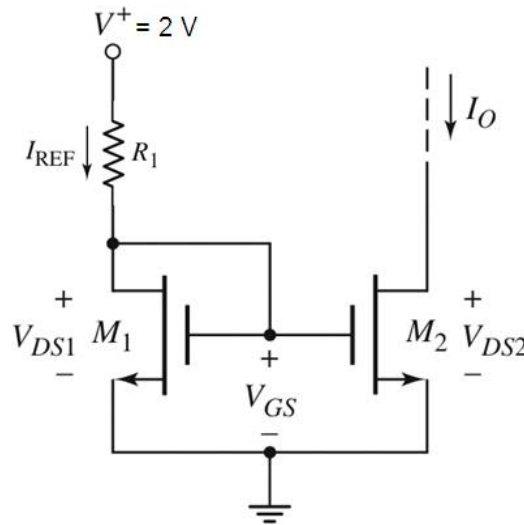


Figure 1

$$V_{DS2}(\text{sat}) = V_{GS} - V_{TN} \quad [1]$$

$$\begin{aligned} V_{GS} &= V_{DS2}(\text{sat}) + V_{TN} \\ &= 0.3 + 0.5 = 0.8 \text{ V} \end{aligned} \quad [1]$$

$$I_{REF} = (V^+ - V_{GS} - 0) / R_1 \quad [1]$$

$$\begin{aligned} R_1 &= (V^+ - V_{GS} - 0) / I_{REF} \\ &= (2 - 0.8) / (80\mu) = 15 \text{ k}\Omega \end{aligned} \quad [1]$$

$$I_{REF} = (k'_n / 2) (W/L)_1 [V_{GS} - V_{TN}]^2 \quad [1]$$

$$(W/L)_1 = I_{REF} / \{(k'_n / 2) [V_{GS} - V_{TN}]^2\} \quad [1]$$

$$\begin{aligned} &= (80\mu) / \{(50\mu/2) [0.8 - 0.5]^2\} \\ &= 35.556 \end{aligned} \quad [1]$$

$$I_O = (k'_n / 2) (W/L)_2 [V_{GS} - V_{TN}]^2 \quad [1]$$

$$(W/L)_2 = I_O / \{(k'_n / 2) [V_{GS} - V_{TN}]^2\} \quad [1]$$

$$\begin{aligned} &= (100\mu) / \{(50\mu/2) [0.8 - 0.5]^2\} \\ &= 44.444 \end{aligned} \quad [1]$$

; N – MOSFET

$$v_{DS}(\text{sat}) = v_{GS} - V_{TN}$$

$$i_D = K_n [v_{GS} - V_{TN}]^2$$

$$K_n = \frac{k'_n \cdot W}{2 \cdot L}$$

; P – MOSFET

$$v_{SD}(\text{sat}) = v_{SG} + V_{TP}$$

$$i_D = K_p [v_{SG} + V_{TP}]^2$$

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