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Lab 8

1. MOSFET Characterization

(a), (b) $K_n = 0.6335421167 \ mA/V^2$

$V_{th} = 0.81016 \ V$

(c) done

2. Common Source (CS) Amplifier with Resistive Load

$I_{DS} = \frac{K_n}{2}(V_{in} - V_{th})^2$ $\quad g_m = K_n(V_{in} - V_{th})$

$V_{in} = \frac{V_{dd} + V_m}{1 + \frac{A_v}{2}} + V_{th}$ $\quad A_v > 18 \ dB$

V_{bias}

$A_{v_i} = -g_m (R_D \| r_o)$

(i) $V_{th} = 0.5V$ $\quad K_p = 200 \ mA/V^2$

$A_v > 18 \ dB \Rightarrow 20 \log_{10} A_v > 18$

$\Rightarrow A_v > 7.943$

$A_v = -g_m R_D$

$g_m = K_n(V_{in} - V_{th})$

$g_m R_D > 7.943$

$K_n (V_{in} - V_m) R_D > 7.943$

$0.000633541167 (V_{in} - 0.81016) R_D > 7.943$

$$V_{in} > \frac{12537.46}{R_D} + 0.81016$$

also, $$V_{in} < \frac{V_{DD}}{1 + \frac{A_v}{2}} + V_m$$

taking $R_D = 33\,k\Omega$ $\quad V_{in} = 1.3V = V_{bias}$

$\Rightarrow A_v = 10.24 > 7.943$

doing $$V_{in} = \frac{V_{DD} - V_m}{1 + A_v/2} + V_{th}$$

$\Rightarrow V_m = 2.01\,V$

$$(V_{out})_{DC} = V_{DD} - I_D R_D = V_{DD} - \frac{A_v}{2}(V_{bias} - V_m)$$

$$= 5 - 5.12(1.3 - 0.81016) = 2.49V$$

$V_{gs} = 1.3V$ $\quad V_{ds} = V_{out} = 2.49V$

$I_d = 7 \times 10^{-5}\,A$

$$g_m = K_n (V_{bias} - V_m) = 31 \times 10^{-5}\ A/V$$

Measured $$|A_v| = \left| \frac{2.5526 - 2.3552}{1.290 - 1.309} \right| = 10.3894 \simeq$$ theoretical A_v

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3. Common Source (CS) Amplifier with Diode Connected load

at V_{out} $\quad g_{m2} V_{gs2} = g_{m1} V_{gs1}$ $\qquad V_{gs1} = V_{in}$

$V_{gs2} = -V_{out}$

$g_{m1} = \sqrt{2 I_{d1} K_{n1}}$ $\qquad g_{m2} = \sqrt{2 I_{d2} K_{p2}}$

$$A_V = \frac{V_{out}}{V_{in}} = \frac{-g_{m1}}{g_{m2}} = -\sqrt{\frac{K_{n1}}{K_{p1}}}$$

$$K_{n1} (V_{in} - V_{tn1})^2 = K_{p2} (V_{dd} - V_{out} - V_{tn2})^2$$

$$V_{in} = \sqrt{\frac{K_{p2}}{K_{n1}}} (V_{dd} - V_{out} - V_{tn2}) + V_{tn1}$$

$$V_m = V_{out} - (V_{in} - V_{tn1})$$

$V_{in} = 10mV_{pp}$ 1kHz + V_{bias} $\qquad V_{dd} = 5V$

$K_{n1} = 0.633541167 \ mA/V^2$

$V_{tn1} = 0.81016V$

$K_{p2} = 200 \ \mu A/V^2$

$V_{tn2} = -0.5V$

$$A_V = -\sqrt{\frac{K_{n1}}{K_{p1}}} = -1.78$$

Let $V_m = 1V$

$$\Rightarrow \quad 1 = V_{out} - (V_{in} - 0.81016) \qquad -①$$

$$V_{in} = 17.76755 (5 - V_{out} + 0.5) + 0.81 \qquad -②$$

① $\Rightarrow$ $\Rightarrow \quad V_{out} = V_{in} + 0.189$

② $\Rightarrow$ $\quad -V_{out} = \dfrac{V_{in} - 0.81}{17.76755} - 4.5$

$\Rightarrow \quad -17.76755 V_{in} + 76.595 = V_{in} - 0.81$

$\Rightarrow \quad V_{in} = V_{bias} = 2.069V$

$\Rightarrow \quad V_{out} = 2.259$

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From simulation ⇒

$$|A_V| = \left| \frac{2.2781 - 2.2471}{2.0601 - 2.077} \right|$$

$$= -1.834 \simeq -1.78 = \text{calculated}$$

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4. Current Mirror (CM) design

$V_{dd} = 8V \qquad I_{ref} = 2mA$

$$I = \frac{k_n}{2}(V_{gs} - V_{tn})^2$$

$$2\times10^{-3} = 633.54 \times 10^{-6}(V_{gs} - 0.810)^2$$

$$\Rightarrow \quad V_{gs} - 0.810 = 2.5128$$

$$\Rightarrow V_{gs} = 3.323V$$

$$V_{gs1} = V_{DS1}$$

$$V_{DS1} = V_{DD} - I_{ref} R$$

$$\Rightarrow \quad 3.323 = 8 - 2\times10^{-3} R \qquad \Rightarrow R = 2339\,\Omega$$

$$I_{copy} = I_{ref} \Rightarrow V_{DS2} = 3.305$$

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