Problem 1 – (30 points)

Assume all diodes are identical and have $V_{DO}=0.7V$, $n=1$, and $V_T=25mV$. Use the constant voltage drop method. Verify that your assumption for the diode operation (i.e. on or off) are correct. Find the following making sure you find the correct operation of the diodes.

a) State your assumptions (diode is on/off).

b) The current $I_{D1}$

c) The current $I_{D2}$

d) The voltage $V_0$

e) Your verification to prove your assumptions for the diodes are correct.

f) If there is noise on the -9V supply of ±1V, what is the total value for $I_{D2}$ (the AC current through diode, D2)? {Hint: remember to use the AC model for the diode}

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Assume D1 off and D2 on

\[ I_{D1} = -2mA \quad \text{\(\therefore\)} \quad \text{Not on} \quad I_{D1} < 0 \quad \text{Can not check} \quad V_0 \]

\[ 15 - 0.7 - I_{D2} \left(\frac{5.3k}{2.3k}\right) = 0 \]

\[ I_{D2} = \frac{14.3}{5.3k} = 2.7m \quad I_{D2} > 0 \quad \text{.. on} \]

\[ I_{D1} = 0 \quad V_0 = +6V \]

AC:

\[ R_d = \frac{hV_T}{I_{D2}} = \frac{1(25m)}{2.7m} = 9.3\Omega \]

\[ I_d2 = \frac{2.3k \cdot 25mA}{5.3k+9.3} \quad \text{\(\Rightarrow\)} \quad I_{D2} = 2.7m \quad \text{\(\therefore\)} \quad \text{No AC contribution} \]
\[ H(s) = \frac{1 \times 10^9 (s+10)^2}{s(s+100k)(s+1k)} = \frac{1 \times 10^9 (10)(10)\left(\frac{s+1}{10}\right)\left(\frac{s+1}{10}\right)}{5 \times 100k \cdot 1k\left(\frac{s+1}{100k}\right)\left(\frac{s+1}{1k}\right)} = \frac{1,000 \left(\frac{s}{10} + 1\right)\left(\frac{s}{10} + 1\right)}{s\left(\frac{s}{100k} + 1\right)\left(\frac{s}{1k} + 1\right)} \]

At \( w = 20k \), magnitude = 80 dB = 100 \sqrt{V}.

Circuit operates between \( w = 1k \) to \( w = 100k \).
Problem 3 – (20 points)

$V_s$ is an AC signal. Both amplifiers have the following characteristics:

$A_v = 10, \quad R_{in} = 20k\Omega, \quad R_o = 100\Omega$

\[ V_L = 10V_3 \cdot \frac{(40k)}{50k} = 8V_3 \]

\[ V_3 = \frac{10V_1(6.7k)}{6.7k+100+4k} \approx 6.2V_1 \]

\[ V_1 = \frac{V_s \cdot 10k}{10k+30k} = \frac{1}{4}V_s \]

\[ V_L = 8 \cdot 6.2 \cdot \frac{1}{4} = 12.4 \frac{V}{V} \]

\[ i_L = \frac{V_L}{40k} = \frac{V_s}{40k} \]

\[ i_s = \frac{V_L}{40k} \cdot \frac{V_L}{V_s} \]

\[ A_p = (12.4)^2 \approx 154 \frac{W}{W} \]

\[ 10 \log (154) \approx 22 \text{ dB} \]

No clipping on output signal if power supply voltages are $> 12.5V$

Otherwise, the output will clip.

(a) Find $A_p = \frac{P_L}{P_s} = \frac{i_L \cdot V_L}{i_s \cdot V_s}$. Express your answer as a ratio (W/W) and in dB. [Round the answer to the nearest whole number]
Problem 4 – (15 points)

Use the circuit below:

\[ \frac{V_o}{V_{in}} = \frac{R_6}{R_5} \frac{R_4 R_3}{R_1 R_2} \left( \frac{S}{1 + \frac{5\text{MHz}}{R_0 R_5}} \right) \left( \frac{S}{1 + \frac{5\mu\text{C} R_1 R_2}{}^2} \right) \]

Use \( f_t = 5\text{MHz} \) for both amplifiers.
State the overall transfer function \( (V_o/V_{in}) \) in terms of \( R_1, R_2, R_3, R_4, R_5, \) and \( R_6. \)
Problem 5 – (10 points)

Redraw or add to the schematic below to show how to reduce the effect of the input bias current. State the symbolic value(s) of any components added to the schematic. State the answer in terms of $R_1$, $R_2$, $R_3$, and $R_4$.

\[ R = R_1 \| (R_3+R_4) \| R_2. \]