Use the circuit below:

\[ V_{in} \rightarrow \text{Amp1} \rightarrow V_1 \rightarrow \text{Amp2} \rightarrow V_0 \]

Use \( f_t = 9 \text{MHz} \) for both amplifiers.

State the overall transfer function \( (V_o/V_{in}) \) by knowing that it is limited in frequency. (Use the above \( f_t \))

\[
\begin{align*}
\text{gain for } \frac{V_1}{V_{in}} &= -\frac{3K}{(2K+12K)} = -\frac{3K}{14K} = -\frac{3}{14} \frac{V}{V} \\
\text{gain for } \frac{V_o}{V_1} &= -\frac{36K}{(3K+14K)} = -\frac{36K}{17K} = -\frac{36}{17} \frac{V}{V}
\end{align*}
\]

Because of frequency limit, \( f < f_t \)

\[
\begin{align*}
\frac{V_1}{V_{in}} &= -\frac{3}{\left(\frac{S}{3M} + 1\right)} \\
\frac{V_o}{V_1} &= -\frac{9}{\left(\frac{S}{M} + 1\right)}
\end{align*}
\]

\[
\Rightarrow \frac{V_o}{V_{in}} = \frac{V_1}{V_{in}} \cdot \frac{V_o}{V_1} = \frac{-3}{\left(\frac{S}{3M} + 1\right)} \cdot \frac{-9}{\left(\frac{S}{M} + 1\right)} = \left(\frac{27}{\left(\frac{S}{3M} + 1\right) \left(\frac{S}{M} + 1\right)}\right)
\]
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 $V_o$
e) Your verification to prove your assumptions for the diodes are correct.
f) If there is noise on the 2V 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]

Assume $D1$ off, $D2$ on:

$$-2 - I_{D2} (100) - I_{D2} (73) - 0.7 + 20 = 0$$

$$I_{D2} (173) = 18 - 0.7$$

$$I_{D2} = \frac{17.3}{173} = 0.1A$$

$$I_{D1} = 0$$

or $$-2 - I_{D2} (100) - V_o = 0$$

$$V_o = -2 - 0.7 (100) = -12V$$

Check Assumptions: $I_{D2} > 0 \Rightarrow D2$ on

+10 + $V_{D1} - V_o = 0$

$V_{D1} = -10 + (-12) = -22 < 0.7 \Rightarrow D1$ off

AC model:

$$r_d = \frac{nV_T}{I_{D2}} = \frac{(1)(25)}{0.1} = 250$$

$$I_{D2_{AC}} = \frac{\pm1V}{100 + 73 + r_d} = \pm0.577\mu A$$

$$I_{D2_{total}} = 0.1 \pm 0.577\mu A$$
a) Sketch the Bode (both magnitude & phase) plot for: (label all critical values for both magnitude and phase and show all your work)

\[ H(s) = \frac{600 \text{Meg} \cdot s}{(s + 10k)^2} = \frac{6 \cdot 6 \times 10^6 \cdot s}{(10k)^2 (\frac{s}{10k} + 1)^2} = \frac{6s}{(\frac{s}{10k} + 1)^2} \]

b) What is the estimated magnitude value at \( \omega = 5k \text{ rad/sec} \) (in dB):

\[ 20 \log \left[ \frac{6(5k)}{(\sqrt{(\frac{5k}{10k})^2 + 1})^2} \right] = 87.6 \text{ dB} \]

c) What range of frequency will this circuit operate correctly:

This circuit does not have a flat region of operation.
\[ H(s) = \frac{600 \text{Meg} \cdot s}{(s+10k)^2} = \left( \frac{s}{\frac{5}{10k}+1} \right)^2 \]

At \( w = 1 \Rightarrow 20 \log(6) = 15.6 \text{dB} \)
(solving for $R_o=1k$)

\[ V_1 = \frac{15k}{20k+1k} V_s = \frac{150V_s}{21k} = \frac{30(20k)V_s}{21k} = 28.6V_s \]

\[ V_3 = \frac{30V_s(30k)}{30k+21k} = \frac{30(30k)V_s}{51k} = 17.65V_s \]

\[ V_1 = \frac{V_5 (15k)}{15k+15k} = \frac{1}{2} V_s \]

\[ \frac{V_L}{V_s} = 28.6(17.65)^{\frac{1}{2}} \approx 252 \]

\[ I_L = \frac{V_L}{40k} \]

\[ I_s = \frac{V_s}{30k} \]

\[ A_p = \frac{I_L}{I_s} \frac{V_L}{V_s} = \frac{V_L}{40k \cdot V_s} \frac{V_L}{V_s} = \left( \frac{V_L}{V_s} \right)^2 \frac{3}{4} \]

\[ b. \quad A_p = (252)^2 \frac{3}{4} = 47.6 \text{ K} \quad \text{or} \quad 10 \log (47.6k) = 46.8 \text{ dB} \]

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clipping at $V_s = 47.6 \text{ mV}$
5a. \( V_L = \frac{30V_3 \cdot (20K)}{20K+100K} = \frac{30(20K)V_3}{120K} = 5V_3 \)

\( V_3 = \frac{(30V_3)(30K)}{30K+120K} = \frac{30(30K)V_1}{150K} = 6V_1 \)

\( V_1 = \frac{V_5}{15K} = \frac{1}{2} V_5 \)

\( \frac{V_L}{V_5} = 5 \left( \frac{6}{\frac{1}{2}} \right) = 15 \frac{V}{V} \)

\( I_L = \frac{V_L}{40K} \)

\( I_S = \frac{V_5}{30K} \)

\[ A_p = \frac{I_L}{I_S} \cdot \frac{V_L}{V_S} = \frac{V_L}{40K \cdot V_S} \cdot \frac{V_L}{V_S} = \left( \frac{V_L}{V_S} \right)^2 \left( \frac{3}{4} \right) \]

b. \( A_p = \left( 15 \right)^2 \left( \frac{3}{4} \right) = \frac{168.75 \text{ W}}{\text{W}} \) or \( 10 \log (168.75) = 22.3 \text{ dB} \)
$V_s$ is an AC signal. Assume linear operation. Both amplifiers have the following characteristics:

$A_{\text{av}} = 30$, $R_{\text{in}} = 30k\Omega$, (encircled $R_0 = 1k\Omega$) power supplies = ±12 V

(a) Draw this 2 stage amplifier using the voltage amplifier model. Make sure to label $V_s$, $V_1$, $V_2$, $V_3$, and $V_L$ on the schematic.

(b) Find the voltage gain $V_L/V_s$ without frequency dependence or op amp imperfections.

(c) Find $A_p = \frac{P_L}{P_s} = \frac{i_L \ast V_L}{i_s \ast V_s}$ without considering imperfections of the opamp. Express your answer as a ratio (W/W) and in dB. [Round the answer to the nearest whole number]

(d) For the input $V_s$ as shown (assume op amp is operating in correct frequency), sketch (make the peaks exact and estimate between the peaks) the output at $V_L$ on the graph below.

[Cropped graph showing peaks with text: "CLIPS when $V_s = 8V"]
Use the circuit below:

Use $f_t=15$ MHz for both amplifiers.
State the overall *frequency* transfer function ($V_o/V_{in}$) in terms of $R_1$, $R_2$, $R_3$, $R_4$, $R_5$, and $R_6$.

$$\text{Amp 1} \Rightarrow \frac{V_i}{V_{in}} = -\frac{R_3}{(R_1||R_2)} \left[\frac{S}{15\text{MHz}} + 1\right]$$

$$\text{Amp 2} \Rightarrow \frac{V_o}{V_i} = -\frac{R_6}{(R_4||R_5)} \left[\frac{S}{5\text{MHz}} + 1\right]$$

$$\frac{V_o}{V_{in}} = \left(1 + \frac{R_3}{R_1||R_2}\right)\left(1 + \frac{R_6}{R_4||R_5}\right) \left[\frac{SR_3}{15\text{MHz}(R_1||R_2)} + 1\right]\left[\frac{SR_6}{5\text{MHz}(R_4||R_5)} + 1\right]$$
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 $R_4$. 

\[ R_1 \parallel R_2 \parallel (R_3 + R_4) \]
Given: Assume $V_{DC}=0.6V$, $n=1$, and $V_T=25mV$
Assume identical diodes
Use the constant voltage drop method when appropriate

a) Determine the DC component of the diode current through D1, $i_{D1}$
b) Determine the DC component at the output, $V_o$.
c) Determine the AC component of the diode current through D3, $i_d$.
d) Determine the AC component at the output, $V_o$.
e) What is the total output for $V_o$.

Assume: D1-on, D3-on, D2-off

a. $-10 + I_{D1}(75k) + 0.6V f_{D1}(200) - 10 = 0$
   
   
   $I_{D1} = \frac{20 - 1.2}{75,200} = \frac{18.8}{75,200} = 250\mu$A

   $I_{D1} > 0$ :: D1, D3 on

b. $-V_o + I_{D1}(200) + 0.6 - 10 = 0$
   
   $V_o = I_{D1}(200) - 9.4 = -9.35V$

d. $V_{oa} = -9.35 - 15 = -24.35 < 0$ :: D2 off

c. $V_{ac} = \frac{\sin(60t)(300+rd)}{(75,200 + rd + rd)}$

   $r_d = nV_T = \frac{1(25mV)}{250\mu} = 100$

   $r_d = r_d = r_d = r_d$

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   $r_d = r_d = r_d = r_d$

   $V_{ac} = \frac{\sin(60t)(300)}{(75,400)} = 4m \sin60t$

   $i_d = \frac{\sin(60t)}{75,200 + 200} = 13.3\mu \sin(60t)$

   check validity:

   $V_{ac} = i_d (100) = 1.3m \sin(60t) < 10mV$

   $V_{total} = -9.35 + 4m \sin(60t)$
9.

Assume all diodes are identical and have $V_{DO} = 0.7V$. 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):

D1 - On
D2 - Off

b) The current $I_1$

c) The current $I_2$

d) The current $I_3$

e) The voltage $V_o$

f) Your verification:

\[
\begin{align*}
I_1 &= \frac{10 - V_0 + 0.7}{1k} = \frac{10 - 6.65 + 0.7}{1k} = \frac{2.65}{1k} = 2.65mA \\
I_2 &= 0 \\
I_3 &= \frac{V_0 - 5}{1k} = \frac{6.65 - 5}{1k} = 1.65mA \\
I_1 &= I_3 + 1mA \\
\frac{9.3 - V_0}{1k} &= \frac{V_0 - 5}{1k} + 1mA \\
V_0 &= \left(\frac{1}{1k} + \frac{1}{1k}\right) = \frac{5}{1k} + \frac{9.3}{1k} - 1mA \\
V_0 &= \frac{13.3m}{2mA} = 6.65V
\end{align*}
\]

Verification:

\[I_1 > 0 \implies \text{on}\]

\[V_0 + V_0 = 0 \implies V_0 = -6.65 < 0 \implies \text{off}\]
D2 "on", D1 "on"

\[ +I_1 (1k) - 10 + 0.7 + V_0 = 0 \]

\[ I_1 = \frac{-V_0 + 9.3}{1k} = 10m \geq 0 \text{ on} \]

\[ -V_0 - 0.7 = 0 \]

\[ V_0 = -0.7V. \]

\[ I_3 = \frac{(V_0 - 5)}{1k} = -5.7m \]

\[ I_2 = I_3 + 1m - I_1 \]

\[ I_2 = -5.7m + 1m - 10m = -14.7 < 0 \]

Not valid assumptions

D1 "off", D2 "on"

\[ V_0 = -0.7 \]

\[ I_3 = \frac{(V_0 - 5)}{1k} = -5.7m \]

\[ I_2 = I_3 + 1m = -4.7m < 0 \Rightarrow \text{Not on} \]

\[ -V_0 + 5 - 1m(1k) = 0 \]

\[ V_0 = 5 - 1 = 4V \]

\[ -V_0 - V_{D1} + 10 = 0 \]

\[ V_{D1} = 10 - V_0 = 6V < 0 \Rightarrow \text{Not off} \]

D1, D2 "off"