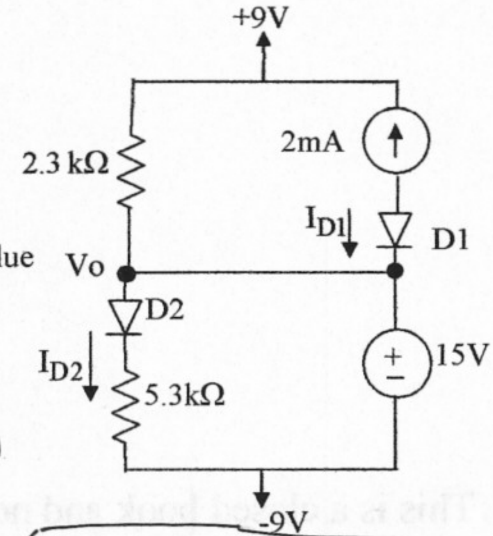
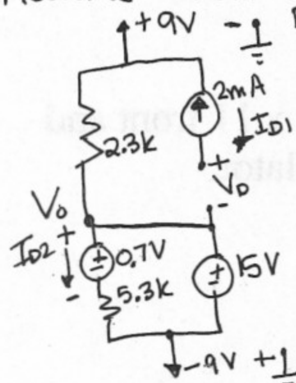
Problem 1 – (30 points)

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 Vo
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}*



Assume D1 off and D2 on



DC: I_{D1} = -2mA ∴ NOT on I_{D1} < 0 → can not check V_D

+15 - 0.7 - I_{D2} (5.3K) = 0

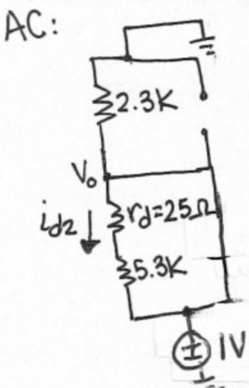
$I_{D2} = \frac{14.3}{5.3K}$ = 2.7m, I_{D2} > 0 ∴ ON

I_{D1} = 0

-9 + 15 - V_o = 0

V_o = +6V

AC:



$r_d = \frac{nV_T}{I_{D2}} = \frac{1(25m)}{2.7m}$ = 9.3ohm

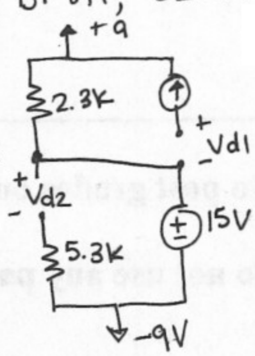
$i_{d2} = \frac{0}{5.3K+9.3}$ = 0 i_{AC}

I_{D2} = 2.7m

∴ no ac contribution

other case:

D1 off, D2 off



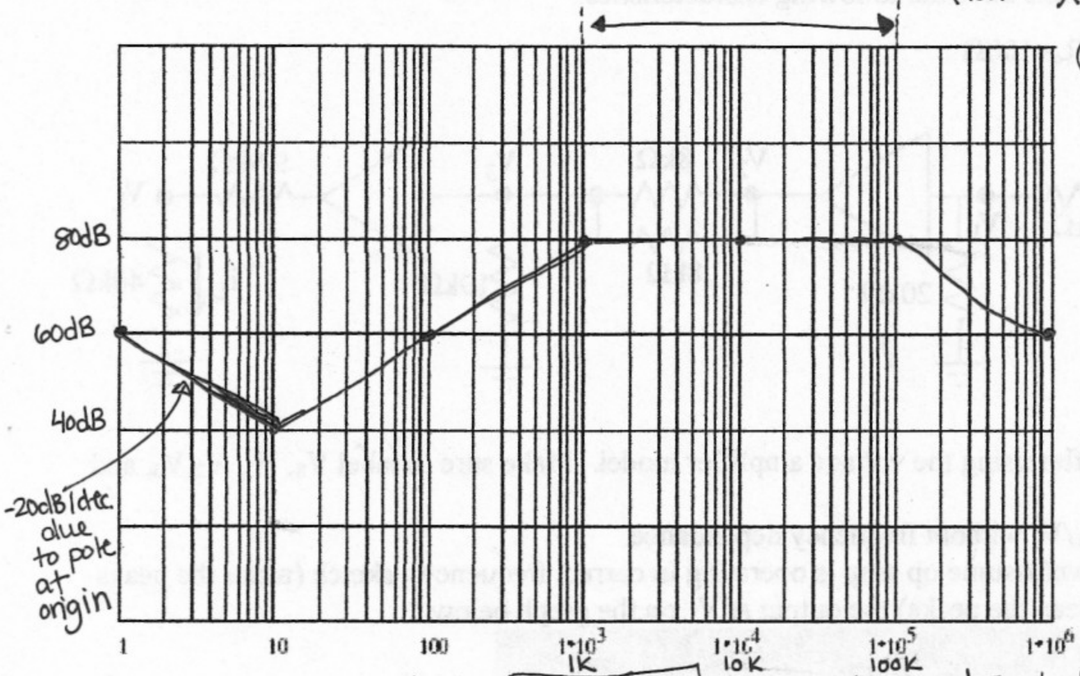
+15 - Vd2 = 0

Vd2 = +15V

Vd2 > 0.7 ∴ Not off

(2)

$$H(s) = \frac{1x10^9 (s+10)^2}{s(s+100k)(s+1k)} = \frac{1\times10^9 (10)(10)\left(\frac{s}{10}+1\right)\left(\frac{s}{10}+1\right)}{s\cdot 100K \cdot 1K \left(\frac{s}{100K}+1\right)\left(\frac{s}{1K}+1\right)} = \frac{1{,}000\left(\frac{s}{10}+1\right)\left(\frac{s}{10}+1\right)}{s\left(\frac{s}{100K}+1\right)\left(\frac{s}{1K}+1\right)}$$



@ 10 ⇒ +20dB/dec *2
+45°*2 between $\omega = 1$ to 100

1K ⇒ -20dB/dec.
-45° between $\omega = 100$ to 10K

100K ⇒ -20dB/dec.
-45° between $\omega = 10K$ to 1 Meg.

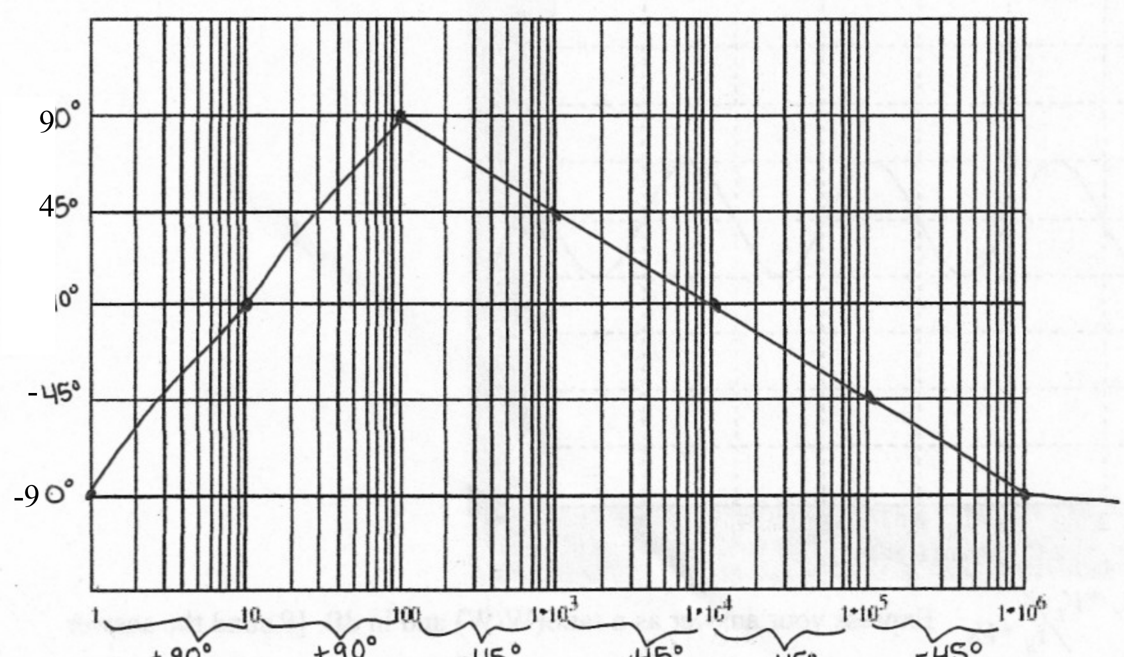
magnitude at $\omega = 1$ ⇒

$$\frac{1{,}000\left[\sqrt{\left(\frac{1}{10}\right)^2+1^2}\right]^2}{1\cdot\sqrt{\left(\frac{1}{100K}\right)^2+1^2}\cdot\sqrt{\left(\frac{1}{1K}\right)^2+1^2}} = 1{,}000 = 60dB$$

slope is -20dB/dec through $\omega = 1$ at 60dB

at $\omega = 20K$, magnitude = **80dB = 100 V/V**

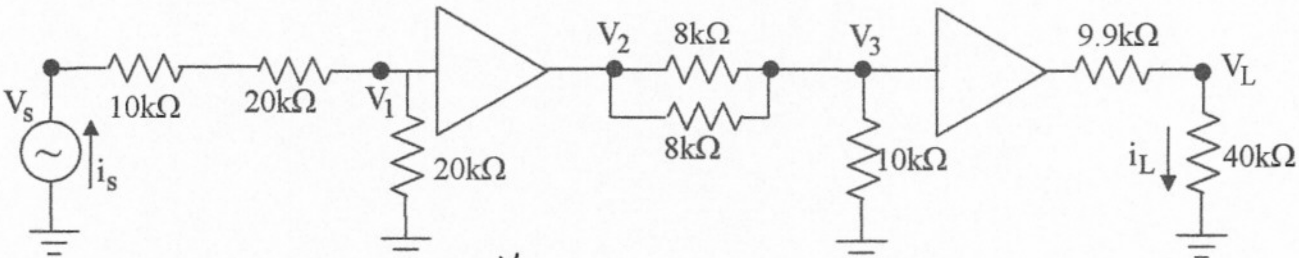
∴ circuit operates between $\omega = 1K$ to $\omega = 100K$

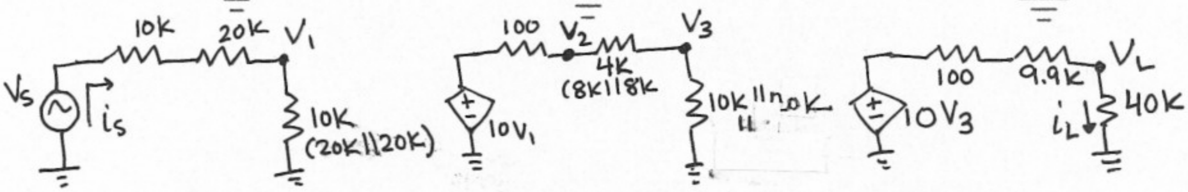


Problem 3 – (20 points)

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

$A_{vo}=10$, $R_{in}=20k\Omega$, $R_o=100\Omega$





$V_L = \frac{10V_3(40k)}{50k} = 8V_3$

$V_3 = \frac{10V_1(6.7k)}{6.7k+100+4k} \cong 6.2V_1$

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

$\frac{V_L}{V_s} = 8 \cdot 6.2 \cdot \frac{1}{4} \cong$ **12.4 V/V**

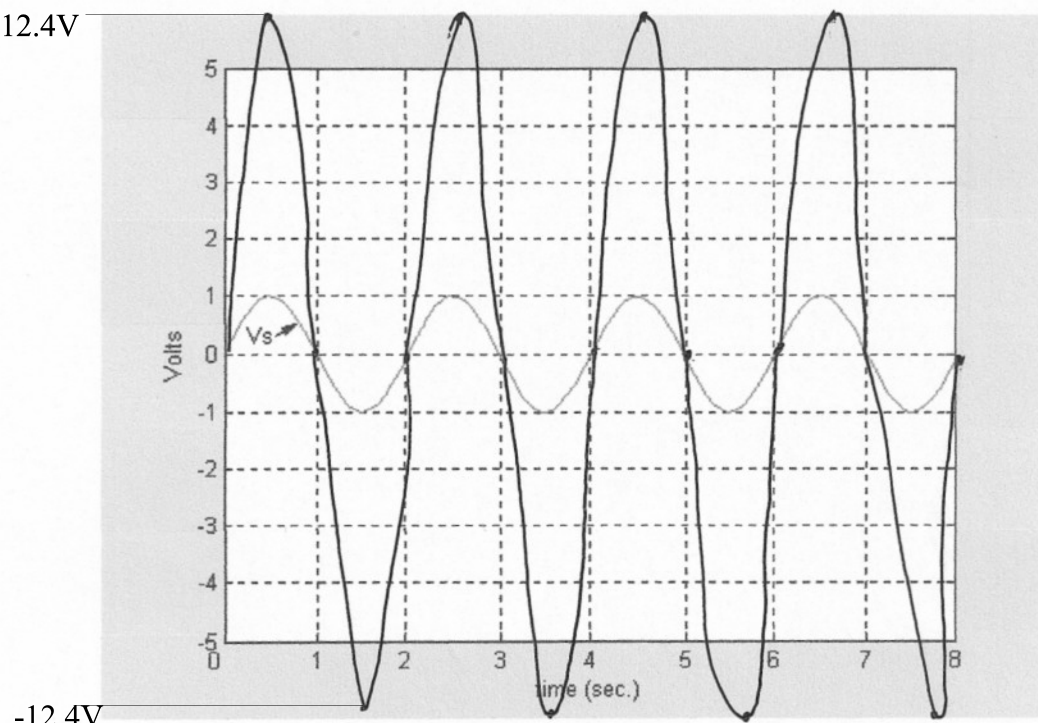
$i_L = \frac{V_L}{40k}$

$i_s = \frac{V_s}{40k}$

$\therefore A_p = \frac{i_L \cdot V_L}{i_s \cdot V_s} = \frac{V_L}{40k} \cdot \frac{V_L}{V_s} \cdot \frac{40k}{V_s}$

$A_p = (12.4)^2 \cong$ **154 W/W**

$10 \log(154) \cong$ **22 dB**

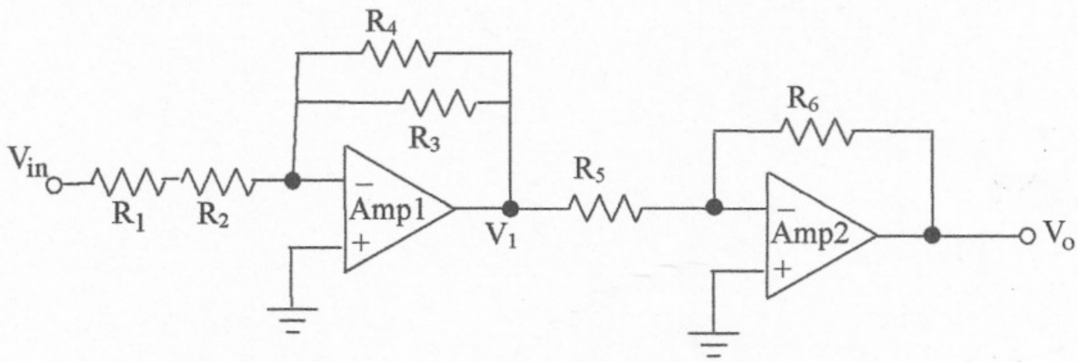


No clipping on output signal if power supply voltages are > 12.5V. Otherwise, the output will clip.

(a) Find $A_P = \frac{P_L}{P_S} = \frac{i_L * V_L}{i_s * Vs}$. 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:



Use f_T=5MHz 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.

$$\frac{V_o}{V_{in}} = \frac{+\ R_6/R_5 \cdot \frac{(R_4 \| R_3)}{R_1+R_2}}{\left(1+\frac{s}{\left(\frac{5MHz}{R_6/R_5}\right)}\right)\left(1+\frac{s\,(R_4\|R_3)}{5M(R_1+R_2)}\right)}$$

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.