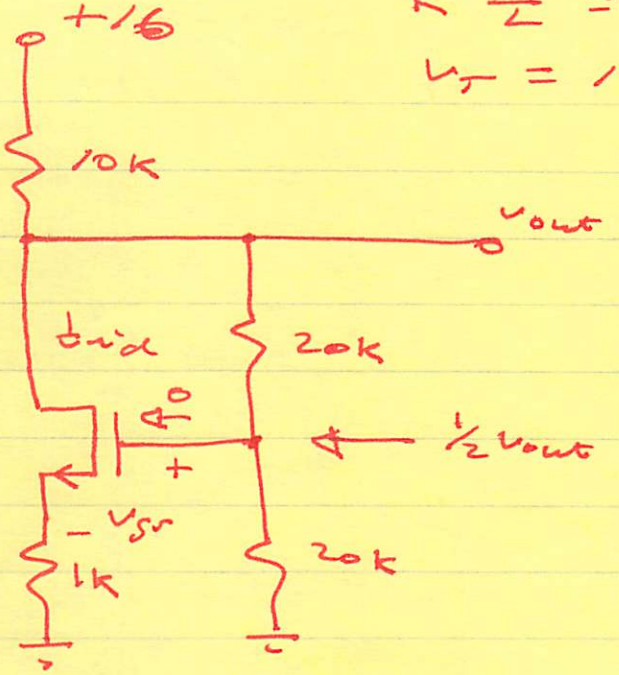
11.10 a)

$K'\frac{W}{L} = 2\,mA/V^2$

$V_T = 1\,V$



Drawing circuit

$$\frac{v_{out}}{40} + i_d = \frac{16 - v_{out}}{10}$$

$$\hookrightarrow \quad v_{out} + 40 i_d = 64 - 4 v_{out}$$

$$5 v_{out} = 64 - 40 i_d$$

$$v_{sr} = \tfrac{1}{2} v_{out} - i_d(1)$$

$$10 v_{sr} = 5 v_{out} - 10 i_d = 64 - 50 i_d$$

$$v_{gr} = 6.4 - 5 i_d$$

sat. $\quad i_d = \tfrac{1}{2}(2)(v_{gr} - 1)^2 = (v_{gr} - 1)^2$

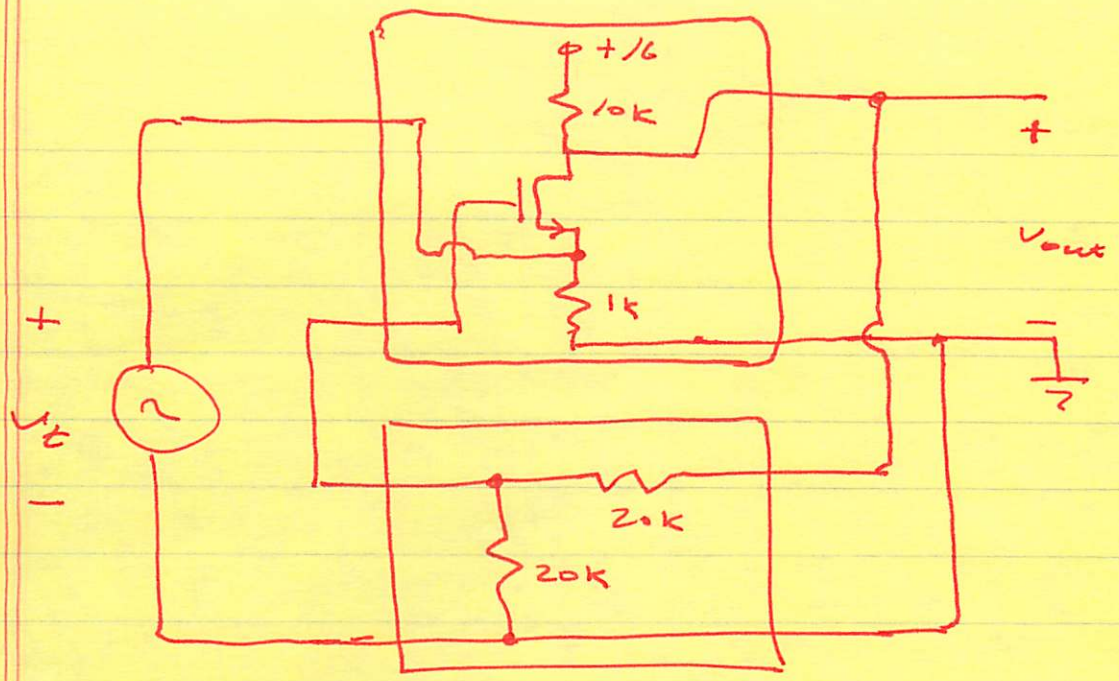
$$v_{sr} = 6.4 - 5 v_{gr}^2 + 10 v_{gr} - 5$$

$$5 v_{gr}^2 - 9 v_{gr} - 1.4 = 0$$

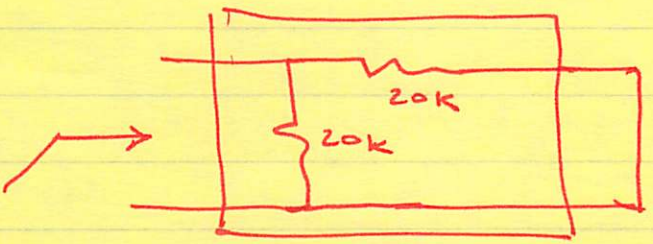
$$v_{gr} = \frac{9 \pm \sqrt{81 + 28}}{10} = 1.94\,V, \cancel{-0.14\,V}$$

$$i_d|_Q = (1.94 - 1)^2 = 0.884\,mA$$

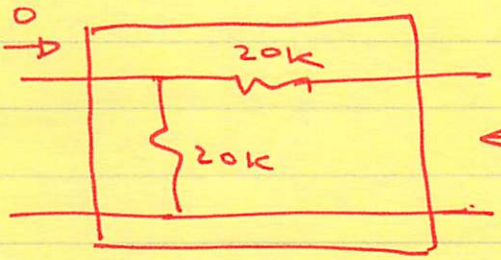
b)



c) Loading from feedback:

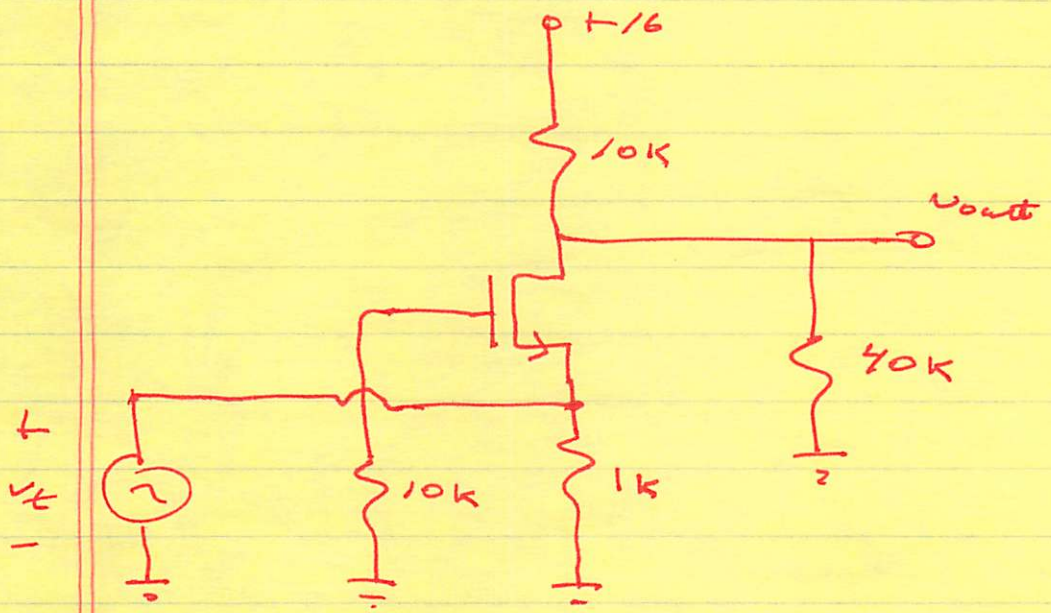


R_{left}
$= 20k \,//\, 20k = 10k$



$R_{right} = 20k + 20k$
$= 40k$

"a" circuit

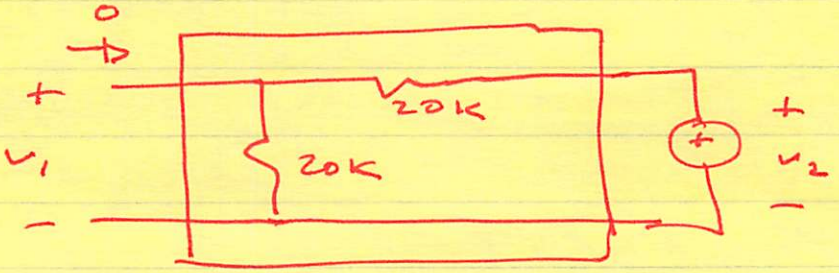


Common gate: $\frac{V_{out}}{V_t} = g_m (10k \,//\, 40k)$ (8k)

$g_m = \sqrt{2 I_{DQ} k' \frac{W}{L}} = \sqrt{2 \times 0.884\,mA \times 2 \frac{mA}{V^2}}$

$= 1.88 \times 10^{-3}\ \Omega$

$a = 1.88 \times 10^{-3}\ \Omega \times 8 \times 10^{3}\ \Omega = 15$

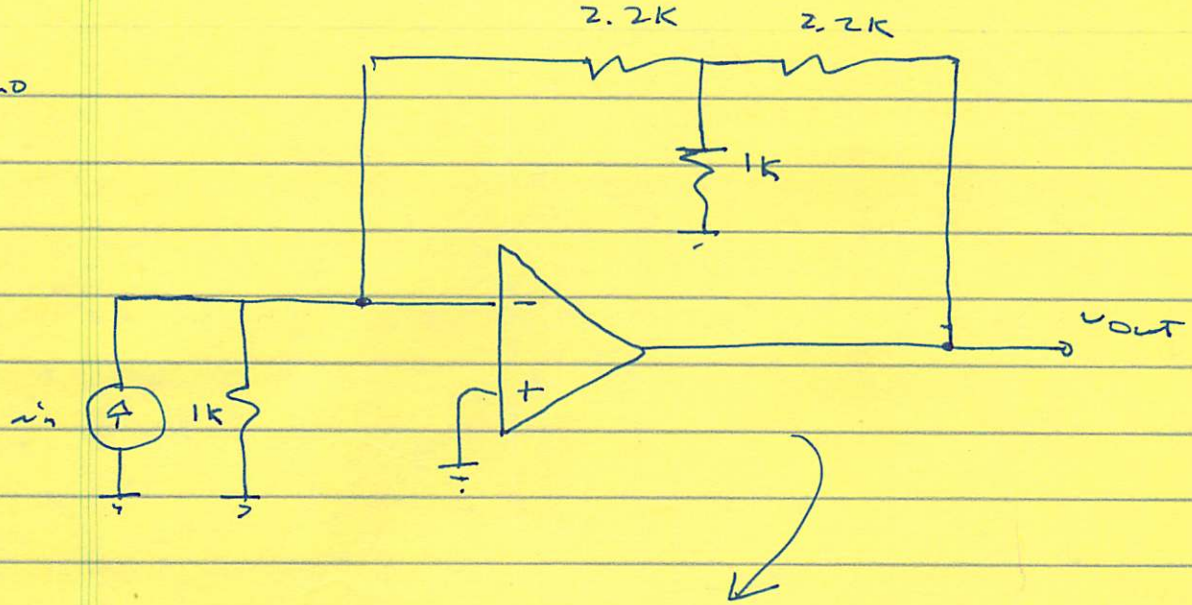


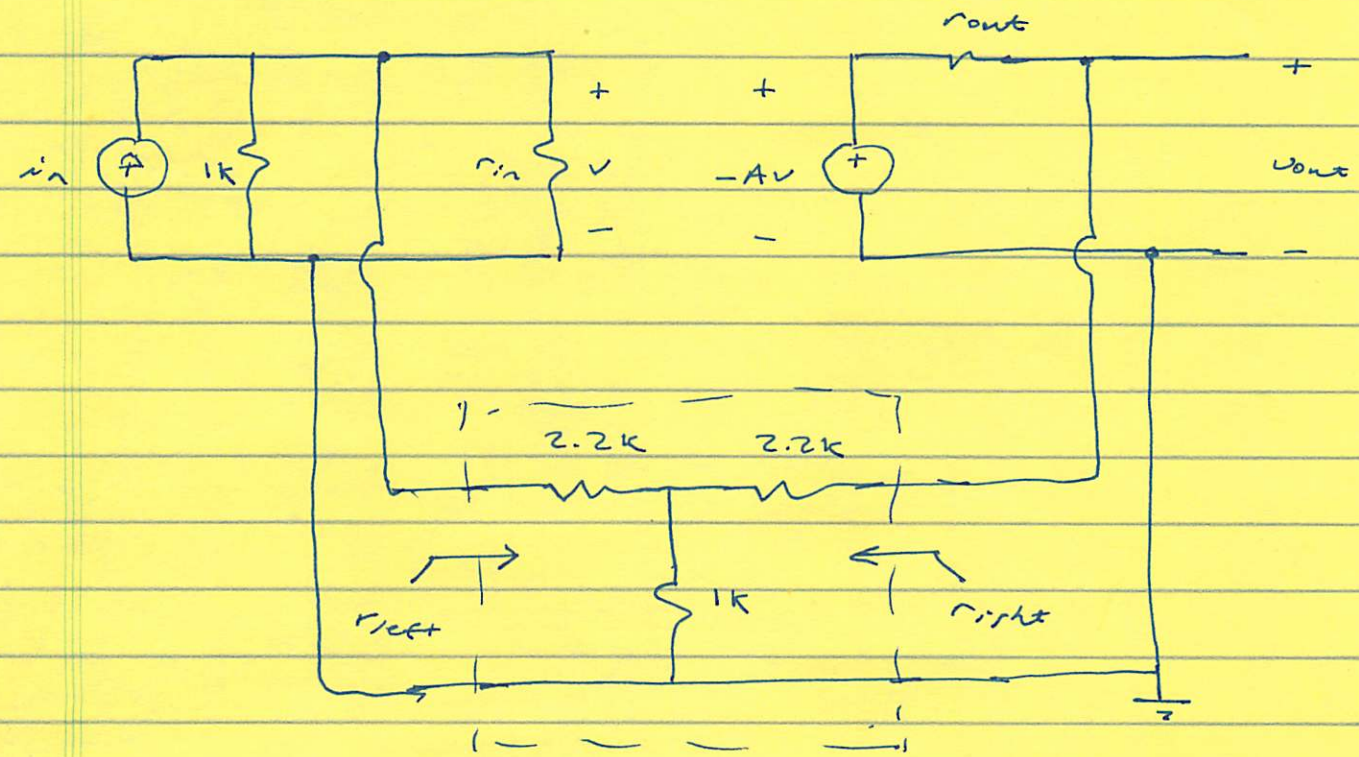
$f = \frac{V_1}{V_2} = \frac{1}{2}$

so with feedback

$\frac{V_{out}}{V_t} = \frac{a}{1 + af} = \frac{15}{1 + 15(0.5)} = \underline{1.77}$

11.20





$r_{in} = 400K$

$r_{out} = 80\,\Omega$

$A = 100{,}000$

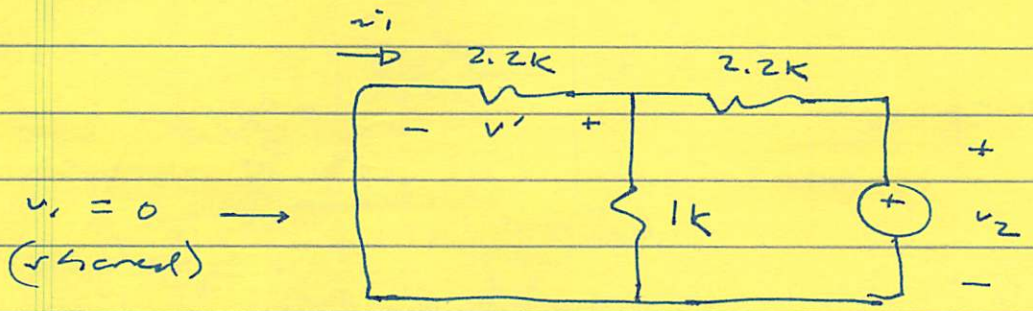
$r_{left} = r_{right} = 2.2K + 1K // 2.2K = 2.89K$

(opposite side shorted, shared voltage)

$$\frac{v}{v_n} = 1k \,//\, 2.89k \,//\, 400k = 742\ \Omega$$

$$v_{out} = -Av \frac{2880}{2880+80} = -97,300\ V$$

$$\frac{v_{out}}{v_{in}} = \frac{v_{out}}{v} \frac{v}{v_{in}} = -7.22 \times 10^{7}\ \Omega = a$$



$$f = \frac{i_1}{v_2}$$

$$v' = v_2 \frac{2.2K \,//\, 1K}{2.2K \,//\, 1K + 2.2K} = 0.278\, v_2$$

$$-i_1 = \frac{0.278 v_2}{2.2K} = -1.08 \times 10^{-4}\ \mho \cdot v_2$$

$$f = -1.08 \times 10^{-4}\ \mho$$

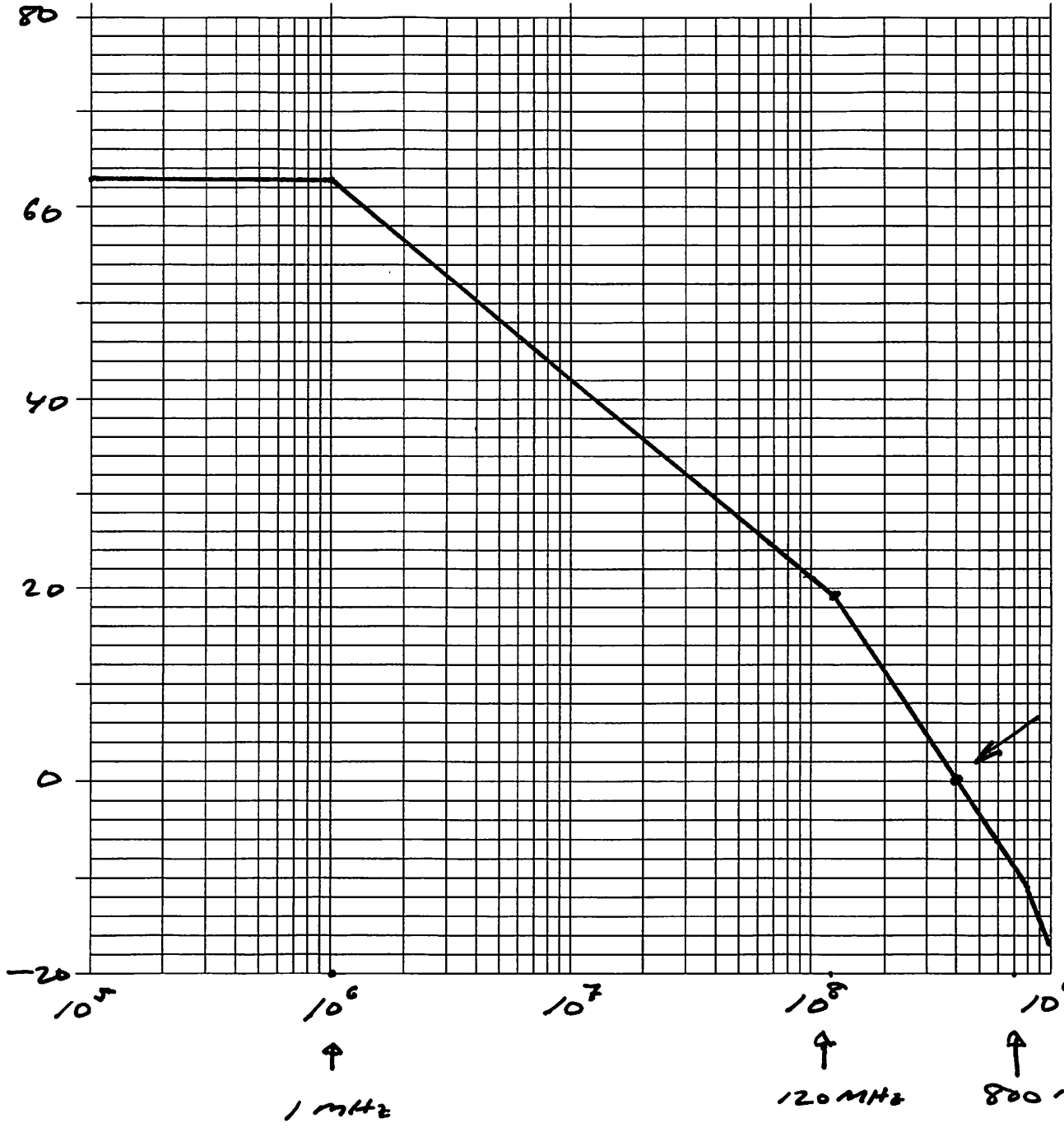
With feedback,

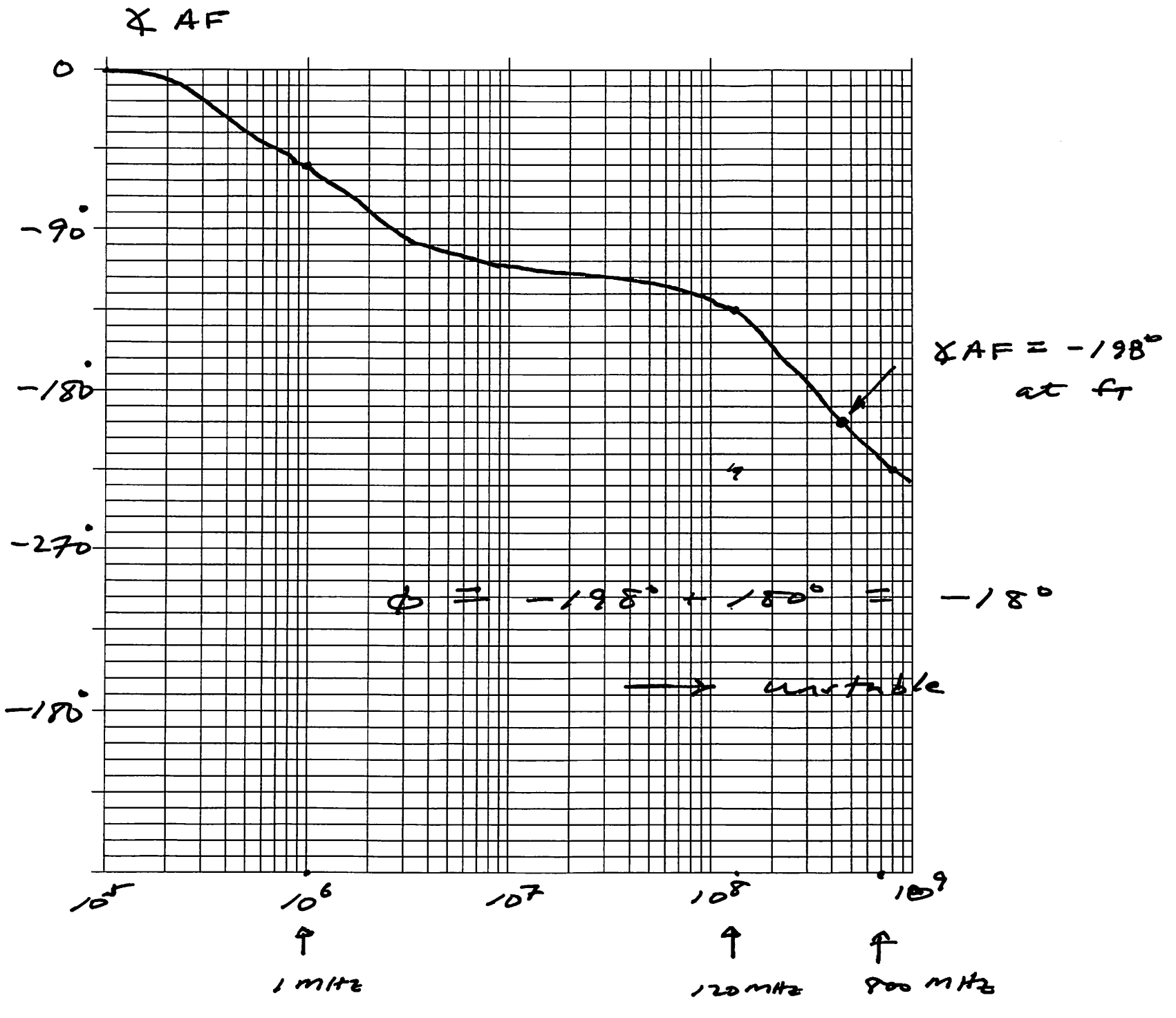
$$\frac{v_{out}}{v_{in}} = \frac{a}{1 + af} = \frac{-7.22 \times 10^{7}\ \Omega}{1 + (-7.22 \times 10^{+7})(-1.08 \times 10^{-4})}$$

$$= -9260\ \Omega$$

$A_0 = 1200 \quad F = 1$

$|AF|_{dB} \qquad A_0F = 1200 = 61.6\ dB$




∠AF
0
-90°
-180°
-270°
-180°
∠AF = -198°
at f_T
ϕ = -198° + -180° = -18°
unstable
10^5
10^6
10^7
10^8
10^9
1 MHz
120 MHz
900 MHz

12.33 $A_0 = 25{,}000$

Let $F = 1$ (worst case)

$f_{p1} = 2\,MHz$, $f_{p2} = 10\,MHz$, $f_{p3} = 80\,MHz$

want $\phi = 60°$

$$f_T = 2\,MHz \tan(90° - 60°) = 1.16\,MHz$$

$$f_{p0} = \frac{1.16\,MHz}{\underbrace{25{,}000}_{A_0 F} \cos(90° - 60°)} = 54\,Hz$$