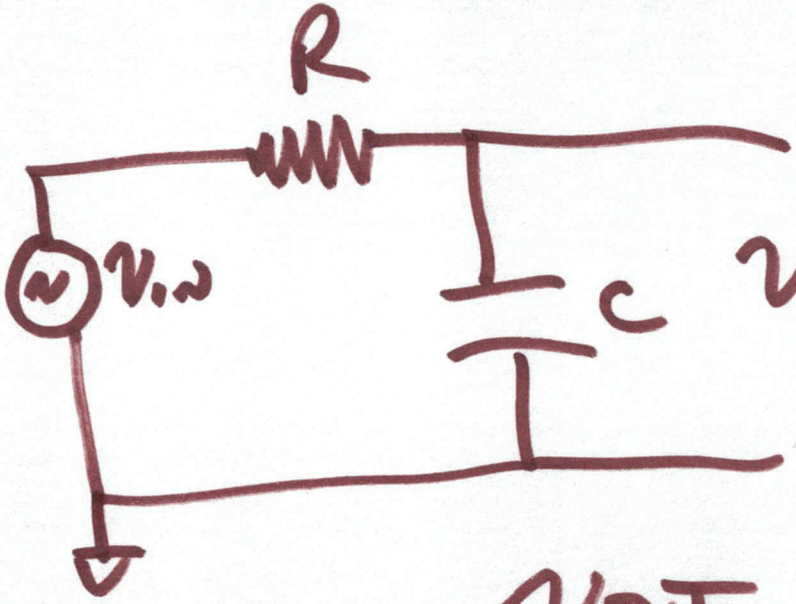
EE 442 / ECE 642
Power Electronics

Lecture 13
October 10, 2022



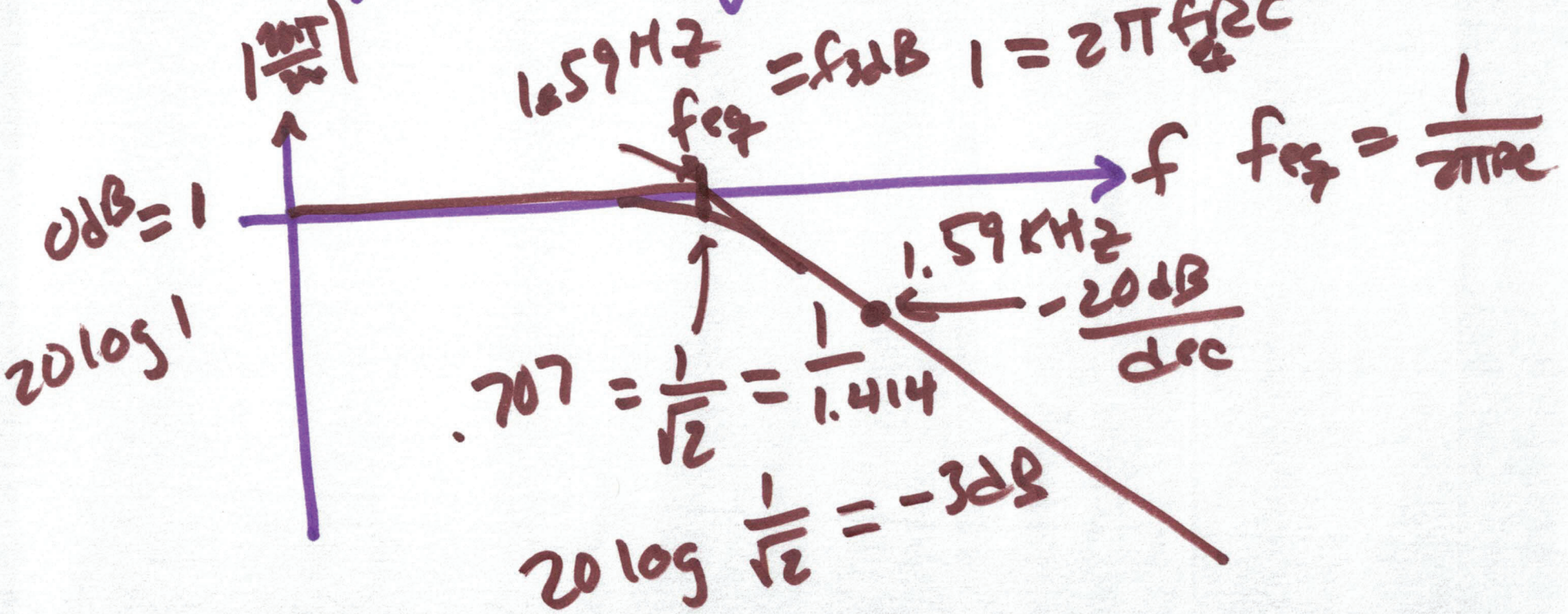
$$v_{out} = v_{in} \cdot \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C} + R}$$

$$\frac{v_{out}}{v_{in}} = \frac{1}{1 + sRC}$$

$$s = j\omega$$

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{1 + j0}{1 + j\omega RC} = \frac{\sqrt{1^2 + 0^2}}{\sqrt{1^2 + (2\pi f \cdot RC)^2}}$$

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\sqrt{1 + (2\pi f RC)^2}} = \frac{1}{\sqrt{1 + \left(\frac{f}{f_{3dB}}\right)^2}}$$



$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\sqrt{1+\left(\frac{f}{f_{3dB}}\right)^2}} \approx \frac{f_{3dB}}{f}$$

$f \gg f_{3dB}$

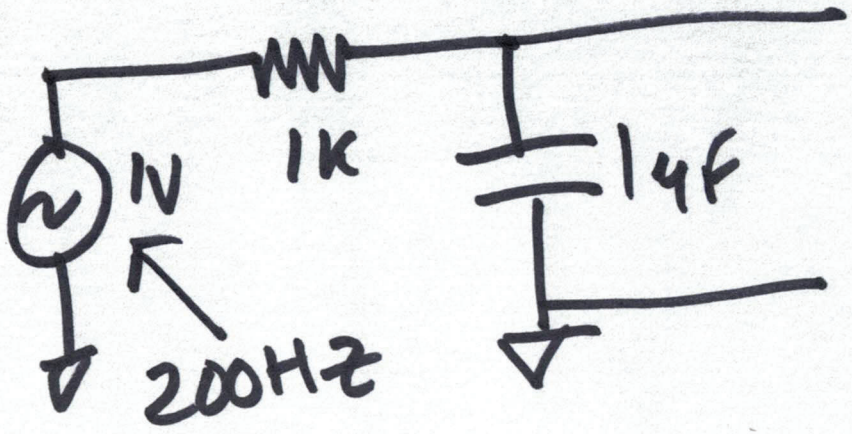
1 decade $\times 10$

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{159\ Hz}{f} = \frac{159}{1590} = \frac{1}{10}$$

1.59 KHz

$$20 \log \frac{1}{10} = -20\ dB$$

$$20 \log 10^{-1} = -20 \log 10$$



$$f_{3dB} = \frac{1}{2\pi \cdot 10^3 \cdot 10^{-6}}$$

$$= 159\,Hz$$

$$V_{out} = 1 \cdot \frac{1}{\sqrt{1 + \left(\frac{200}{159}\right)^2}} = \boxed{.622V = V_{out}}$$

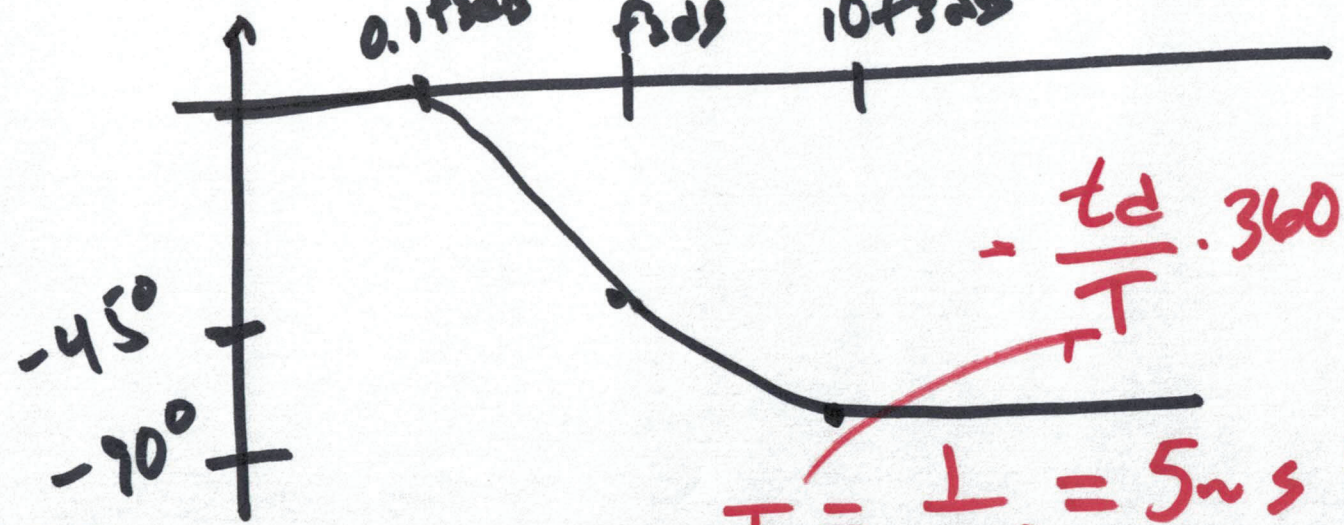
4)

$$\frac{V_{out}}{V_{in}} = \frac{1}{1 + j\frac{f}{f_{3dB}}} = \frac{1 + j0}{1 + j2\pi f RC}$$

$$\angle \frac{V_{out}}{V_{in}} = \tan^{-1}\frac{0}{1} \rightarrow -\tan^{-1}\frac{2\pi f RC}{1}$$

$$= -\tan^{-1}\frac{f}{f_{3dB}} = -\tan^{-1}\frac{200}{159}$$

$$= -51.5°$$



$$-\frac{t_d}{T} \cdot 360 = -51.5°$$

leggiu

$$T = \frac{1}{200} = 5ms$$

$$t_d = .72ms$$

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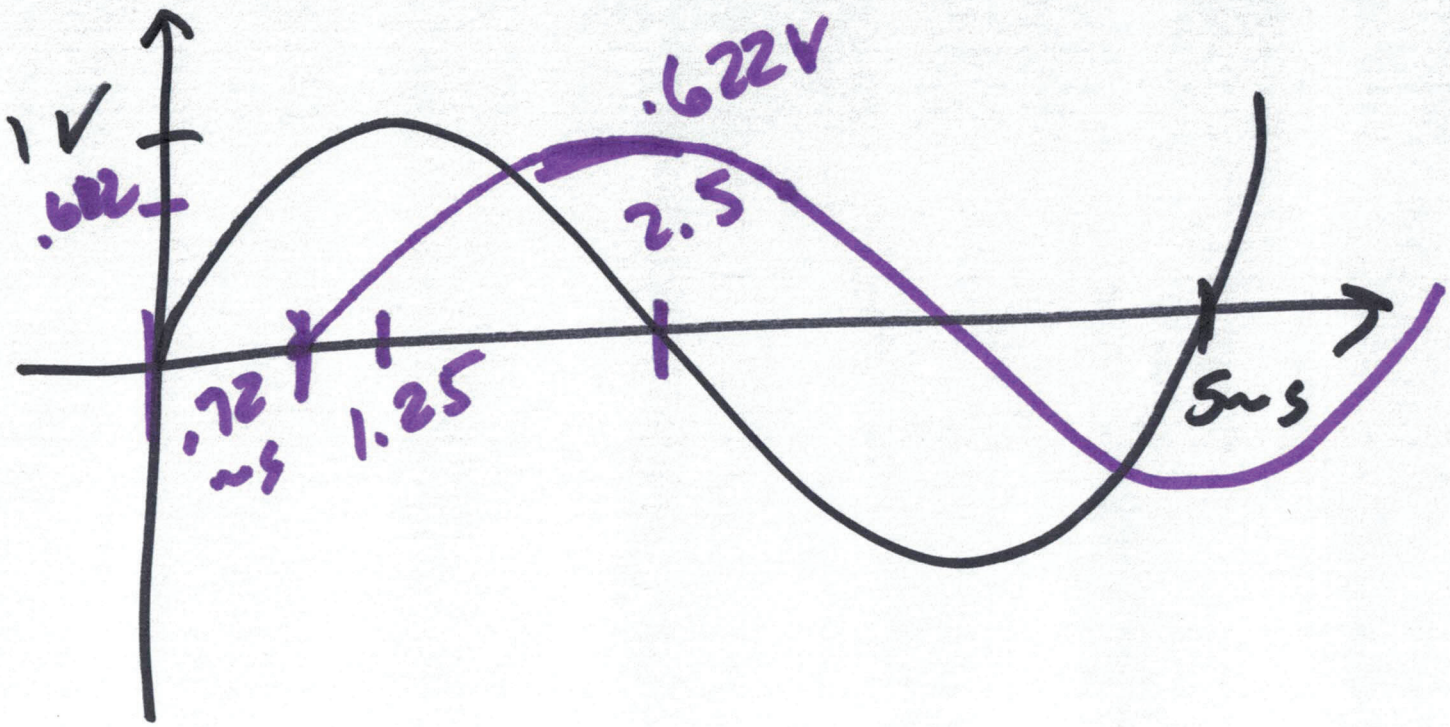
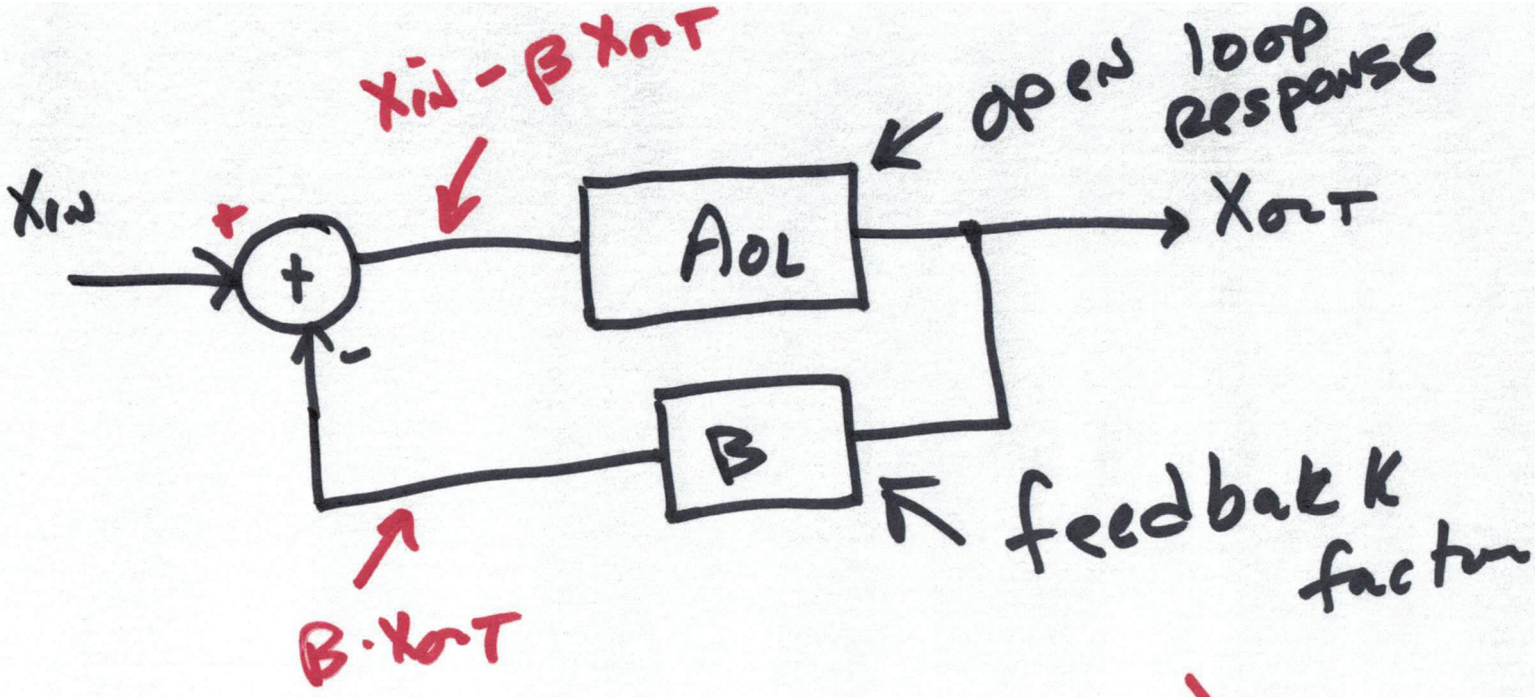

1V
.622
.622V
2.5
.72
~s
1.25
5ns

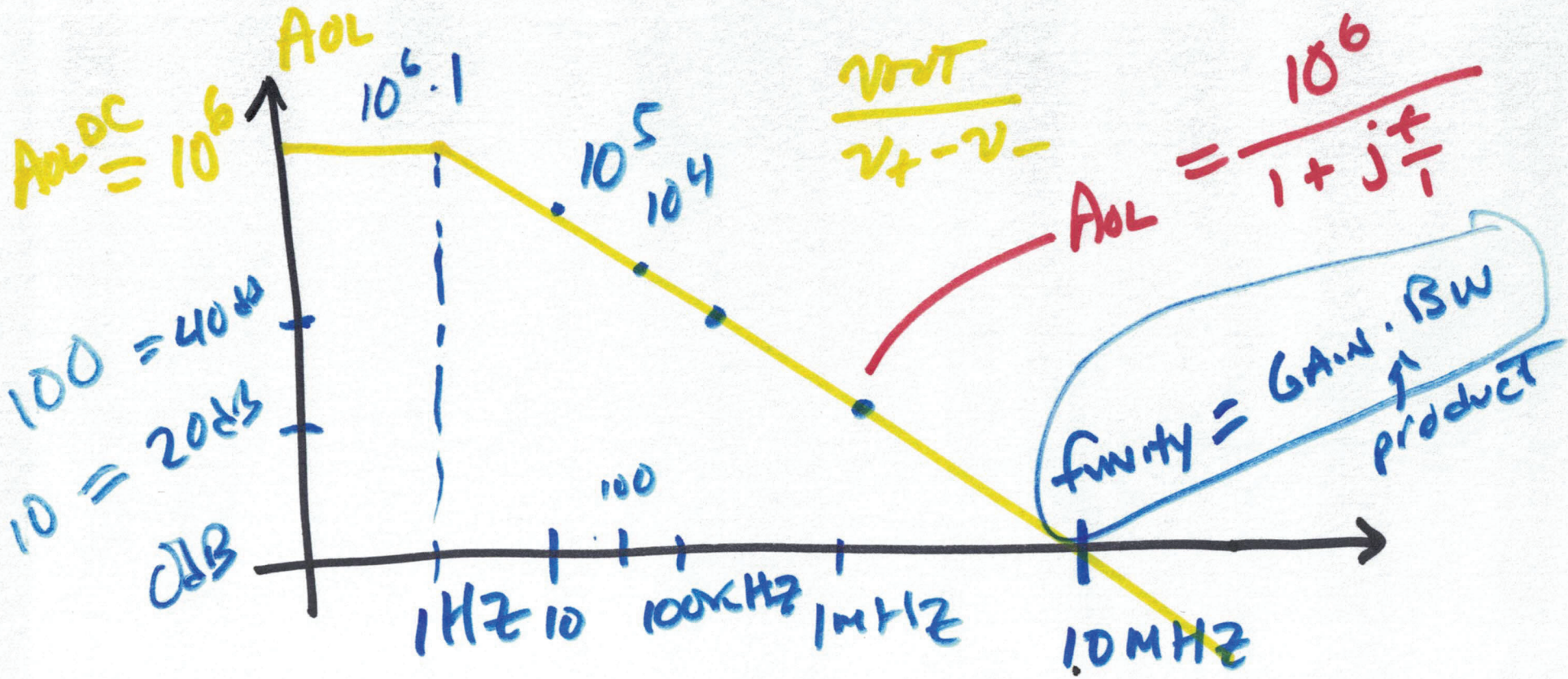


$$X_{OUT} = A_{OL}(X_{IN} - \beta X_{OUT})$$

$$X_{OUT}(1 + \beta A_{OL}) = A_{OL} \cdot X_{IN}$$

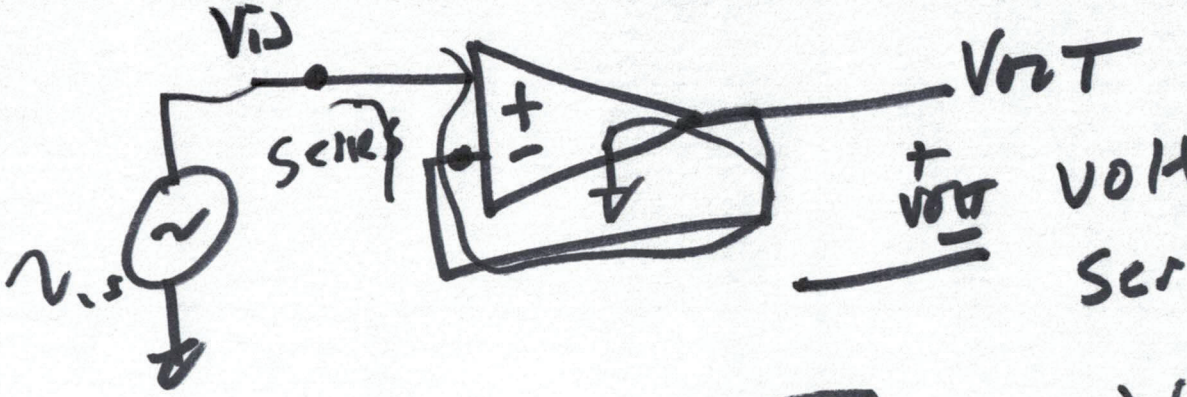
$$\frac{X_{OUT}}{X_{IN}} = \frac{A_{OL}}{1 + \beta A_{OL}}$$

loop gain $= -1$ unstable

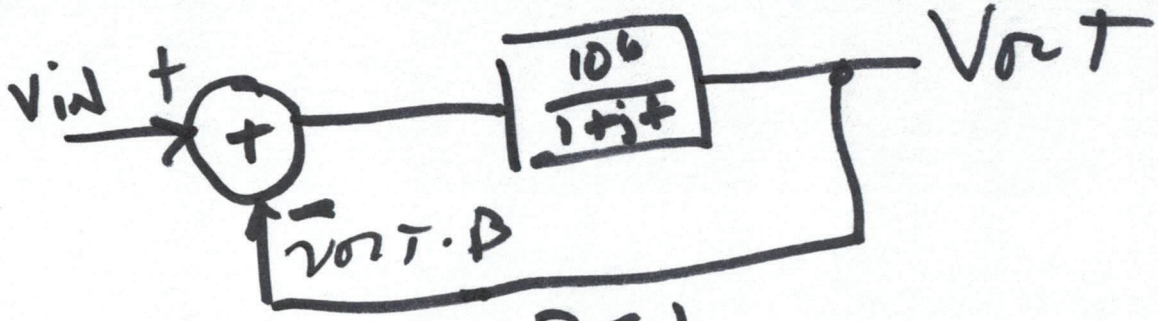

A_{OL}
$A_{OL0} = 10^6$
$10^6 \cdot 1$
10^5
10^4
100 = 40dB
10 = 20dB
0dB
100
1HZ
10
100KHz
1MHZ
10MHZ
$\frac{V_{OUT}}{V_+ - V_-}$
$A_{OL} = \frac{10^6}{1 + j\frac{f}{f_1}}$
funity = GAIN. BW product


V+
V-
+
-
V_{OUT}
$A^0(V_+ - V_-)$

Voltage follower



Voltage - Voltage Series - shunt

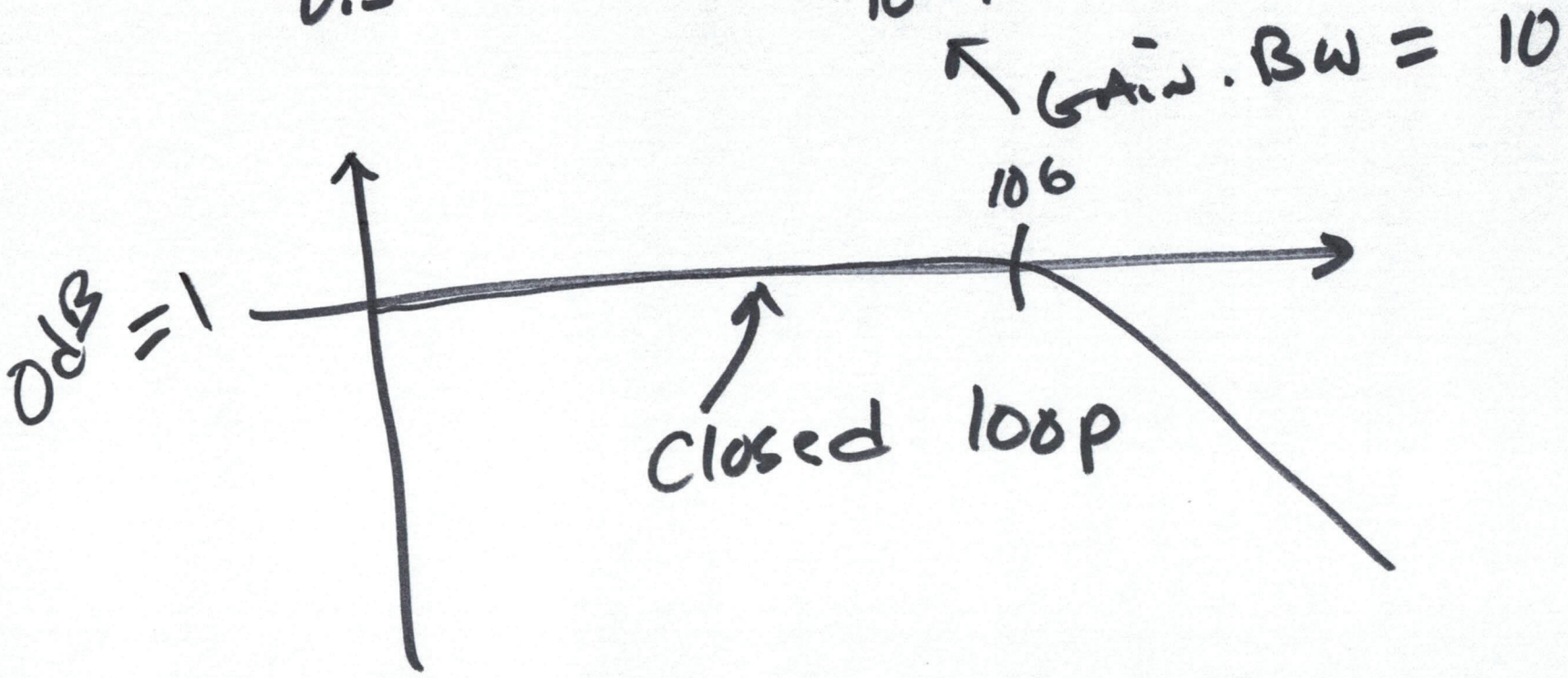


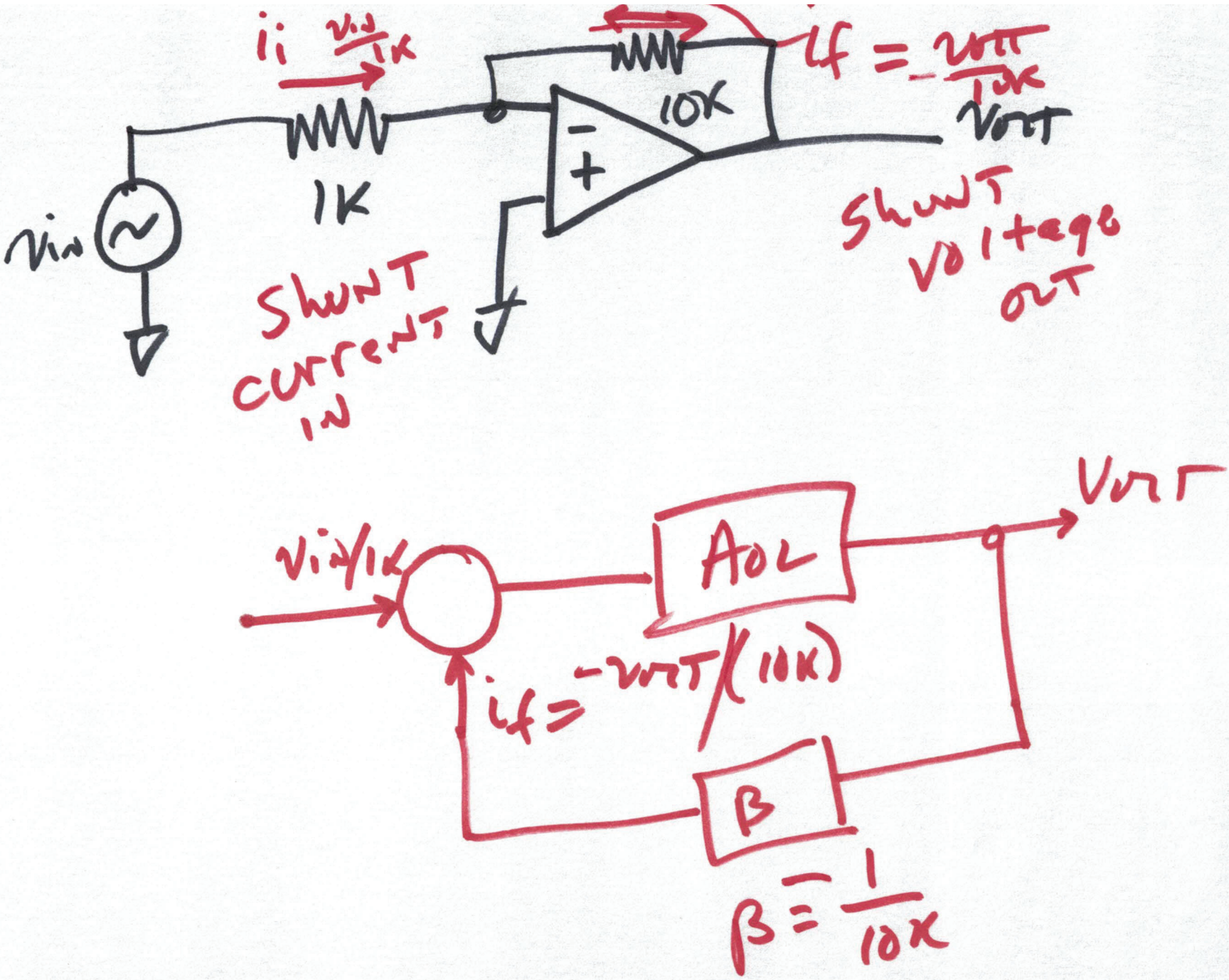
$\beta = 1$

$$\frac{V_{out}}{V_{in}} = \frac{\frac{10^6}{1+jf}}{1+\frac{10^6}{1+jf}} = \frac{10^6}{1+jf+10^6}$$

$$\frac{10^6}{1+j\frac{f}{1}+10^6}$$

$$\frac{V_{out}}{V_{in}} \approx \frac{1}{1 + j\frac{f}{10^6 \cdot 1}}$$




ii
1K
10K
If = -Vout/10K
Vout
Vin
Shunt current in
Shunt voltage out
Vin/1K
AOL
Vout
If = -Vout/(10K)
B
β = 1/10K

$$\frac{V_{OUT}}{i_i} = \frac{A_{OL}}{1 + A_{OL}\cdot\beta} = \frac{1}{\frac{1}{A_{OL}} + \beta}$$

$v_i = i_i \cdot 1K$

$i_i = \frac{v_i}{1K}$

$$= \frac{\frac{1}{1 + j\frac{f}{f_1}}}{10^6} \quad - \quad \frac{1}{10K}$$

$$\frac{V_{OUT}}{i_i} = \frac{1}{\frac{1}{10^6} + j\frac{f}{10^6 \cdot 1}} \quad = \quad \frac{1}{10^4}$$

$\frac{v_i}{1K}$

GAIN · BW product

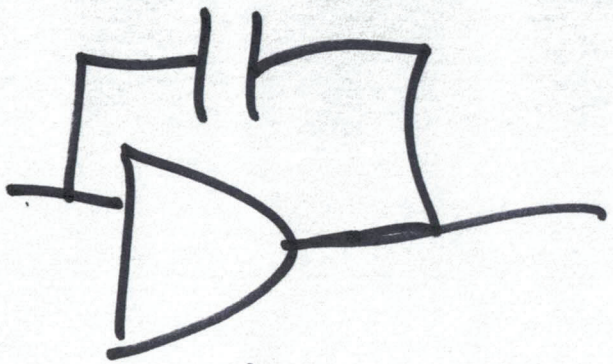
$$\frac{v_{out}}{v_i} = \frac{-\frac{1}{1K}}{\frac{1}{10^6} + j\frac{f}{10^6 \cdot 1} - \frac{1}{10K}}$$

$$= \frac{-\frac{10K}{1K}}{\frac{1}{10^3} + j\frac{f \cdot 10^3}{10^3 \cdot 1} + \frac{10^3}{10^6}\cdot\frac{10^3}{10^3}}$$

$$\simeq \simeq \frac{-\frac{10K}{1K}}{1 + j\frac{f}{10^3}}$$

$$\frac{\frac{1}{1K}}{\frac{1}{10^6} + j\frac{f}{10^6 \cdot 1} + \frac{1}{10K}}$$

$$\frac{\frac{10^6}{10K}}{1 + j\frac{f}{1} + 10^2} = \frac{\frac{10^4}{1K}}{1 + j\frac{f}{10^2} + \frac{1}{10^2}}$$



$\frac{1}{s}$

$$\frac{A_{OL}}{1+\beta A_{OL}}$$

$|\beta A_{OL}| = 1$

$\angle \beta A_{OL} = 180$

$\beta A_{OL} = -1$

B)