EE 320 Lecture 3 1/30/2013

Ideal op-Amp

open loop gain → $A_{OL} = \infty$

NO current into + or − terminals

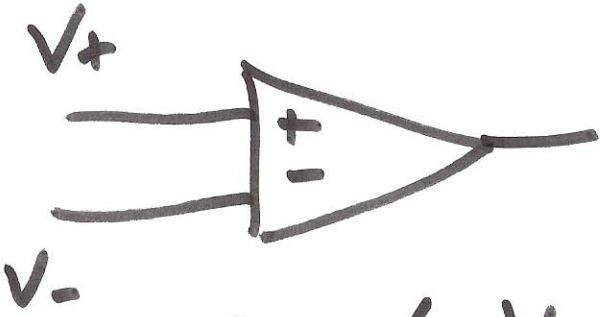
Real op-Amps

finite op-Amp A_{OL}

INPUT-referred offset

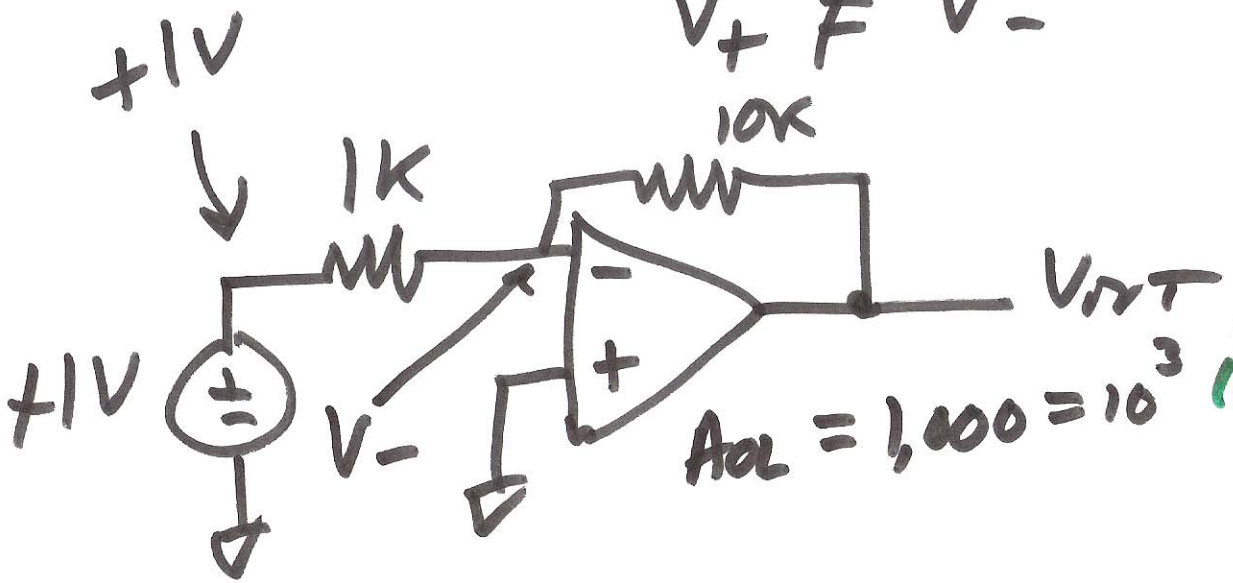
→ GAIN · BW = f_{UN}

finite A_{OL}



$$V_{OUT} = A_{OL}(V_+ - V_-)$$

$V_+ \neq V_-$

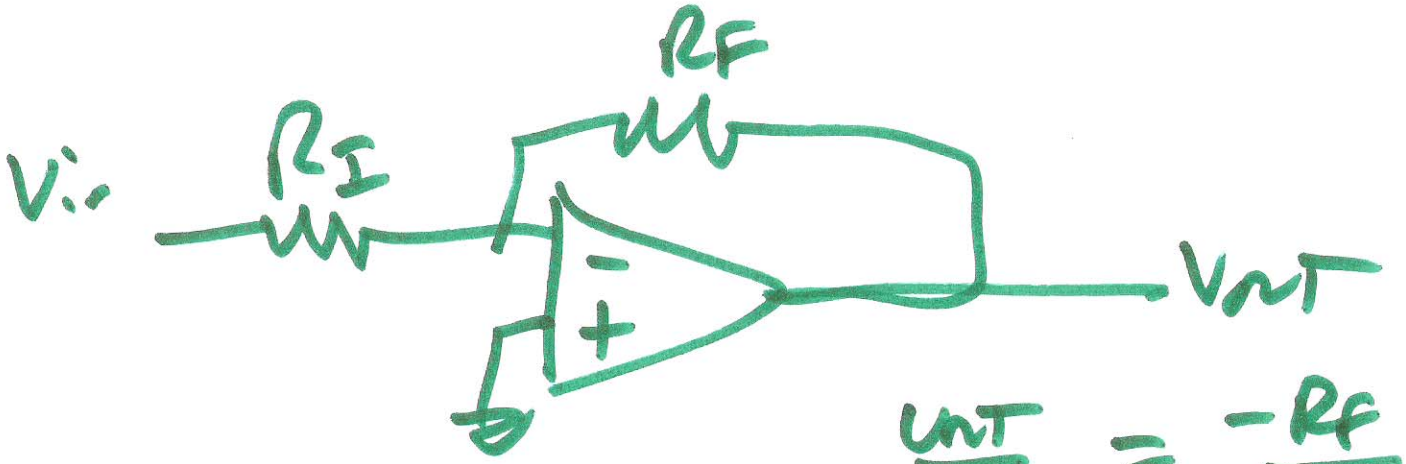


$A_{OL} = 1{,}000 = 10^3$ ideally

$V_{OUT} = -10V$

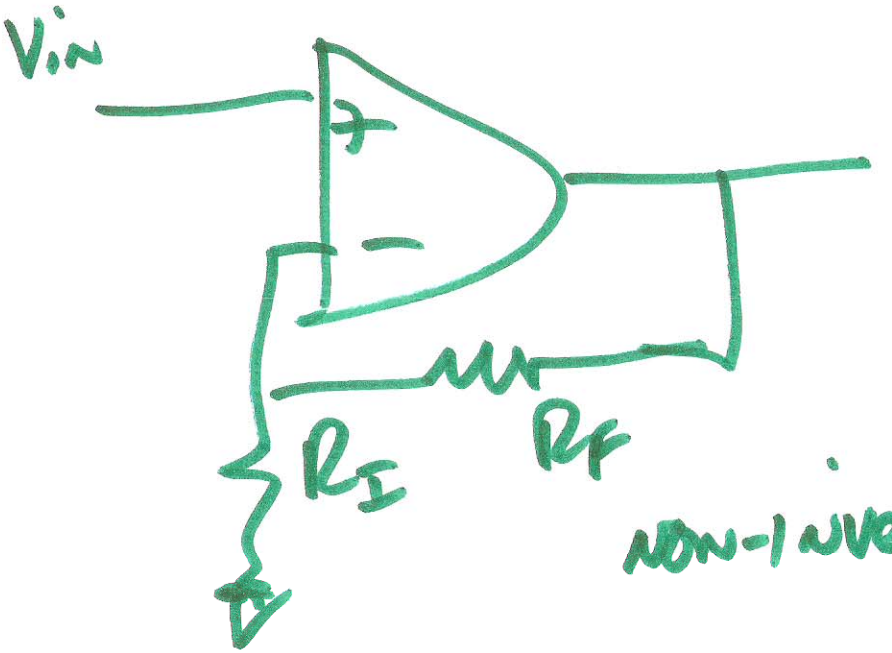
$$\frac{1 - V_-}{1K} = \frac{V_- - V_{OUT}}{10K}$$

$$V_{OUT} = 10^3(0 - V_-) \rightarrow V_- = -\frac{V_{OUT}}{10^3}$$



$$\frac{V_{OUT}}{V_{IN}} = -\frac{R_F}{R_I}$$

INVERTING



$$\frac{V_{OUT}}{V_{IN}} = 1 + \frac{R_F}{R_I} = \frac{R_F + R_I}{R_I}$$

NON-INVERTING

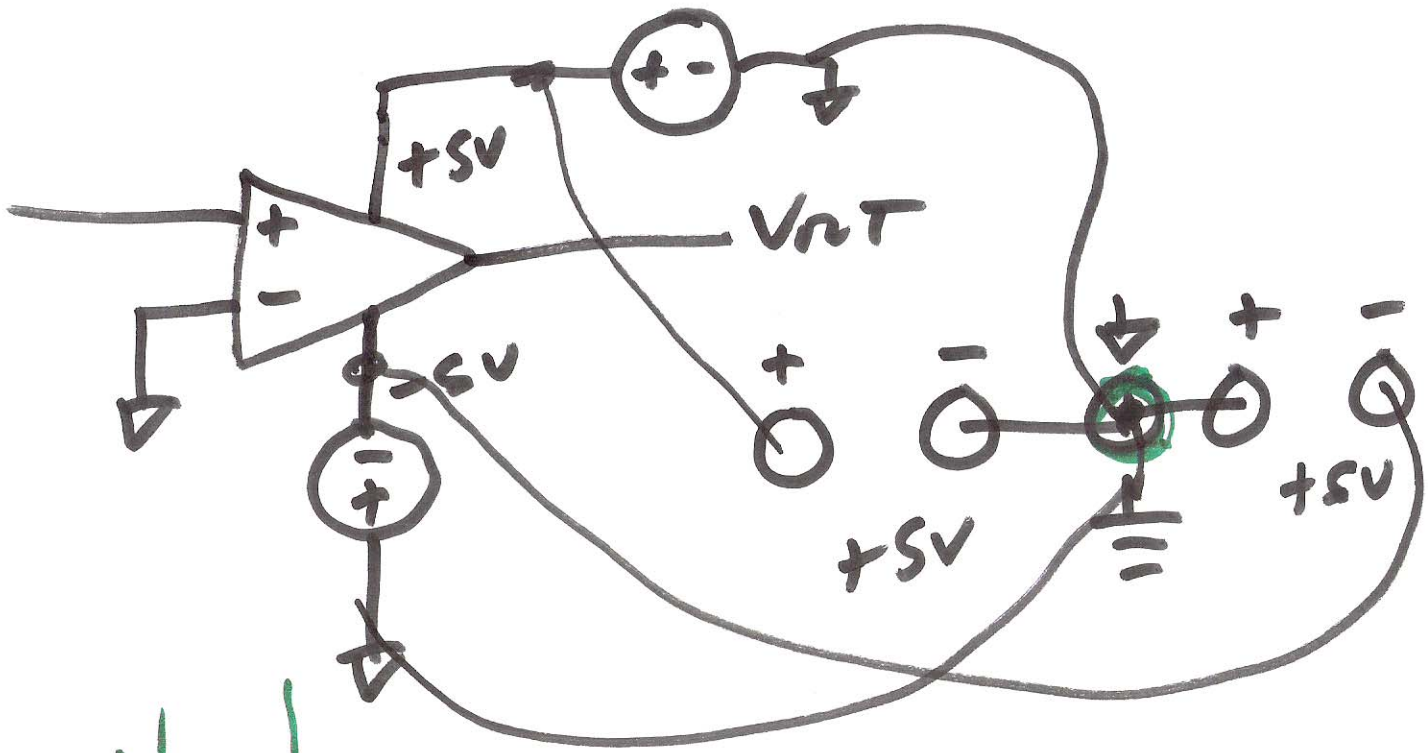
$$10\left(1-\left(\frac{-V_{OUT}}{10^3}\right)\right) = \frac{-V_{OUT}}{10^3}$$

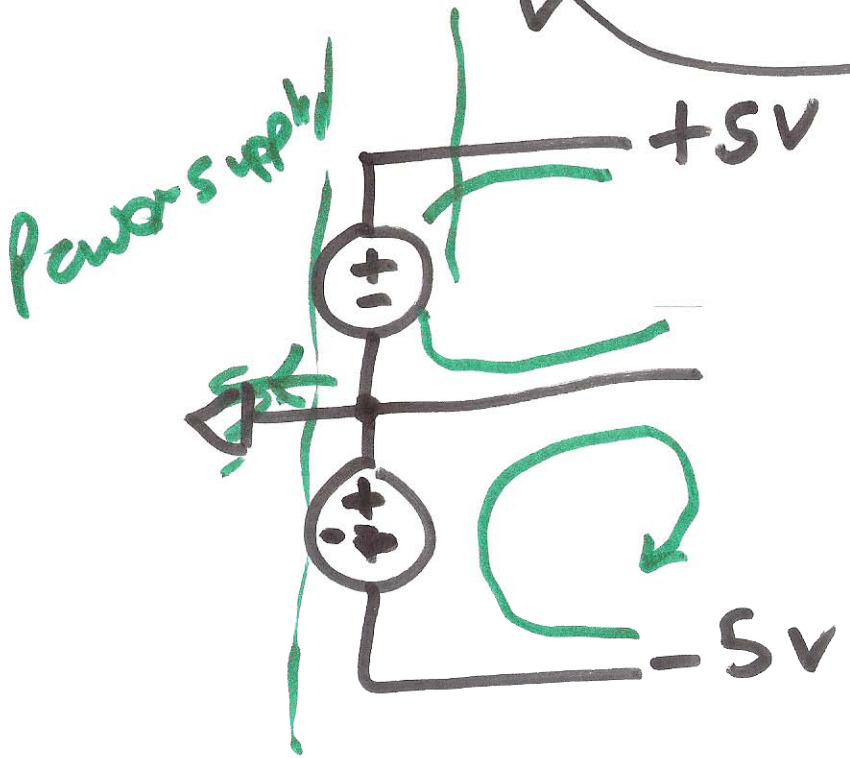
$$10 + \frac{V_{OUT}}{10^2} = -V_{OUT}\left(\frac{1}{10^3}+1\right)$$

$$10 = -V_{OUT}\left(1+\frac{1}{10^2}+\frac{1}{10^3}\right)$$

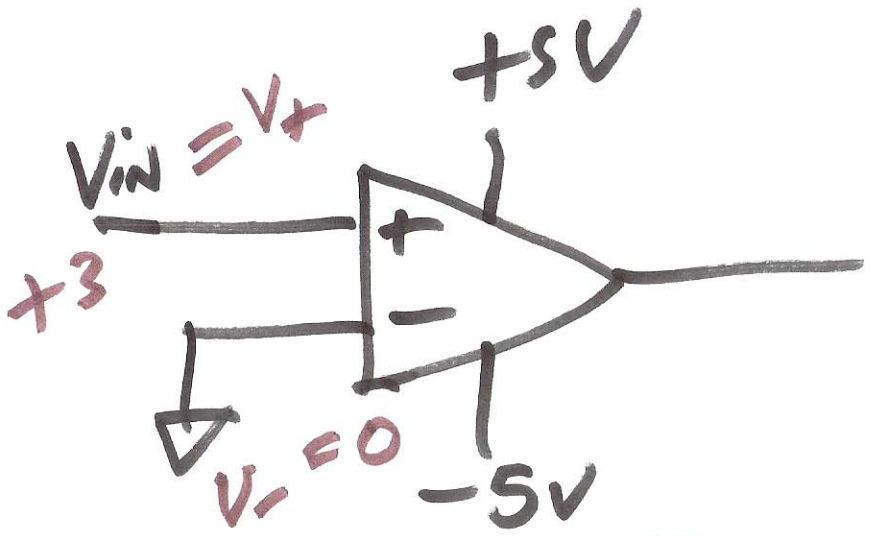
$$V_{OUT} = \frac{-10}{1.011} = \underline{\underline{-9.891}}$$

offset voltage





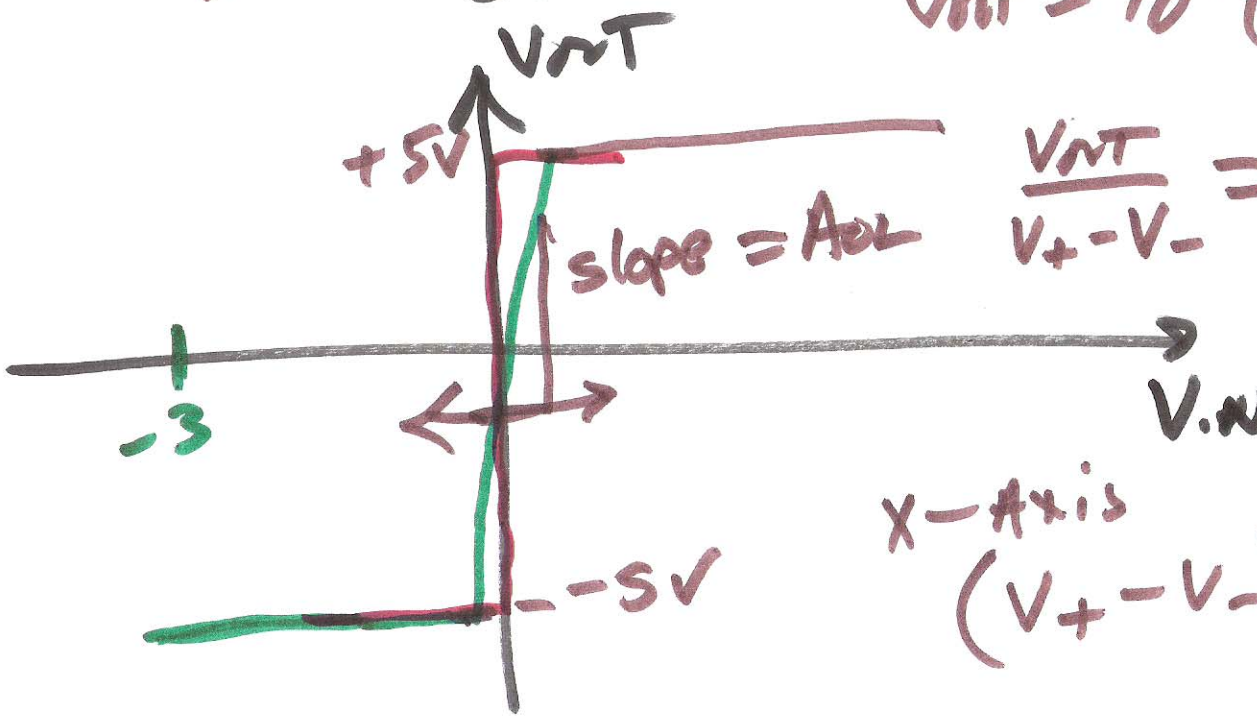
Offset Voltage



$V_{OUT} = A_{OL} \cdot (V_+ - V_-)$

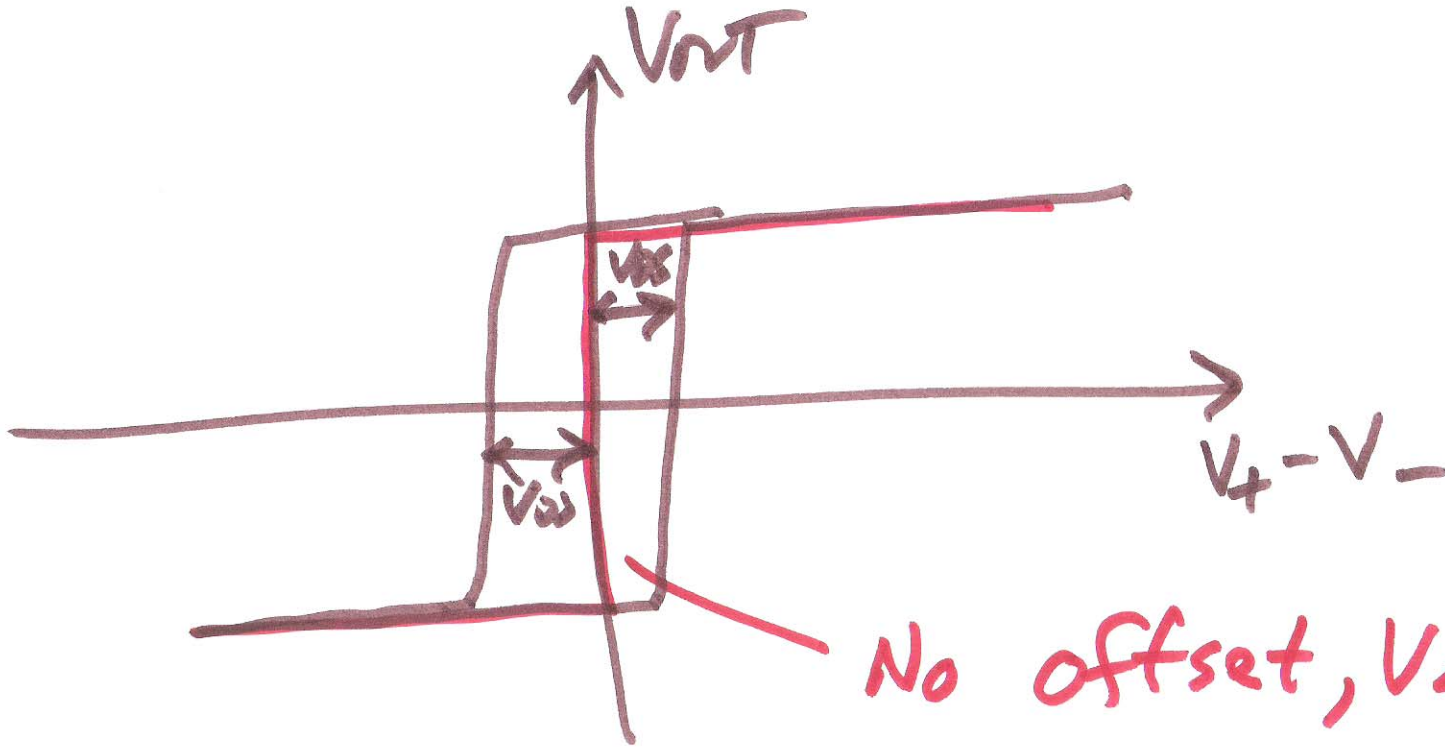
$V_{OUT} = 10^3 (-3 - 0)$

$V_{OUT} = 10^3 (3 - 0)$



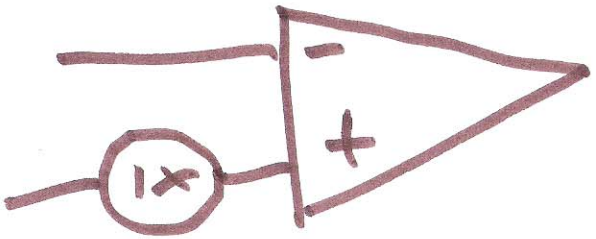
$\frac{V_{OUT}}{V_+ - V_-} = A_{OL}$

x-axis
$(V_+ - V_-)$



No offset, V_{os}

WAY we model offset



V_{os} can be neg. or pos.

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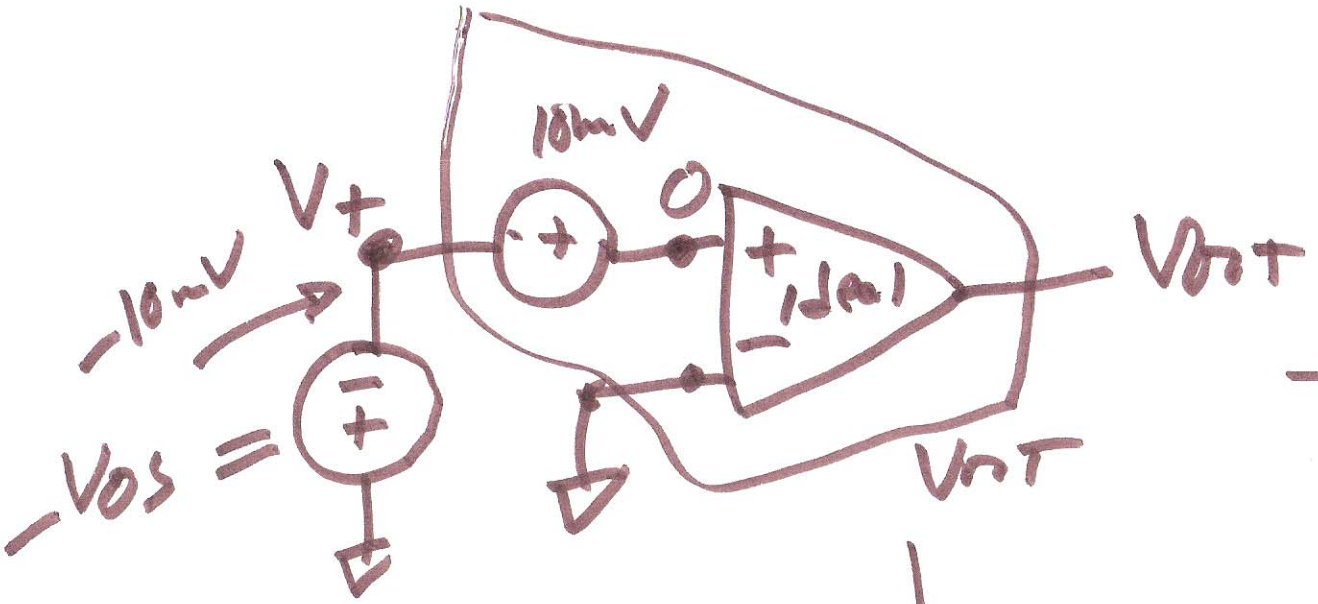
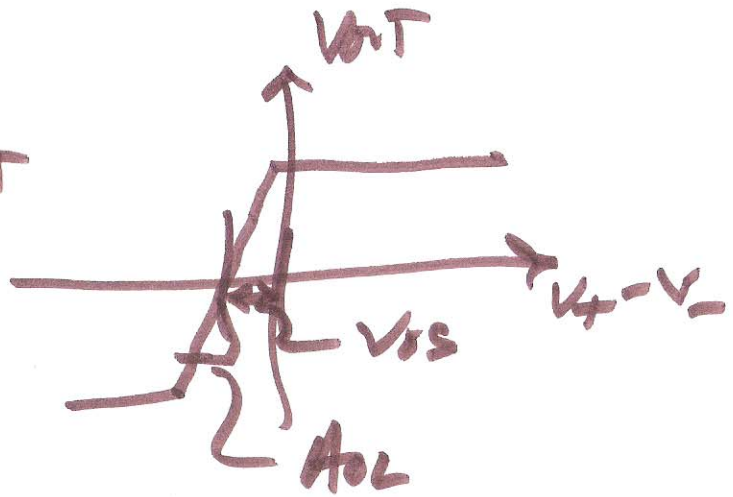
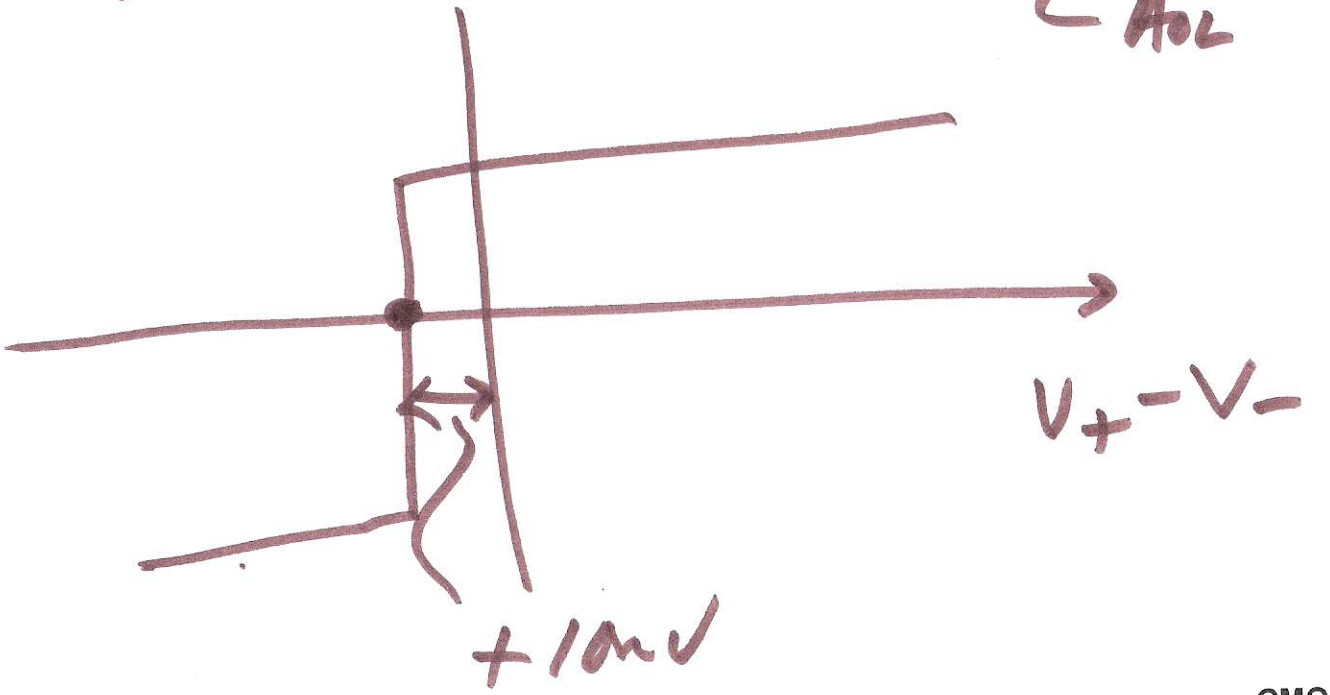
$V_{OS} = +10mV$







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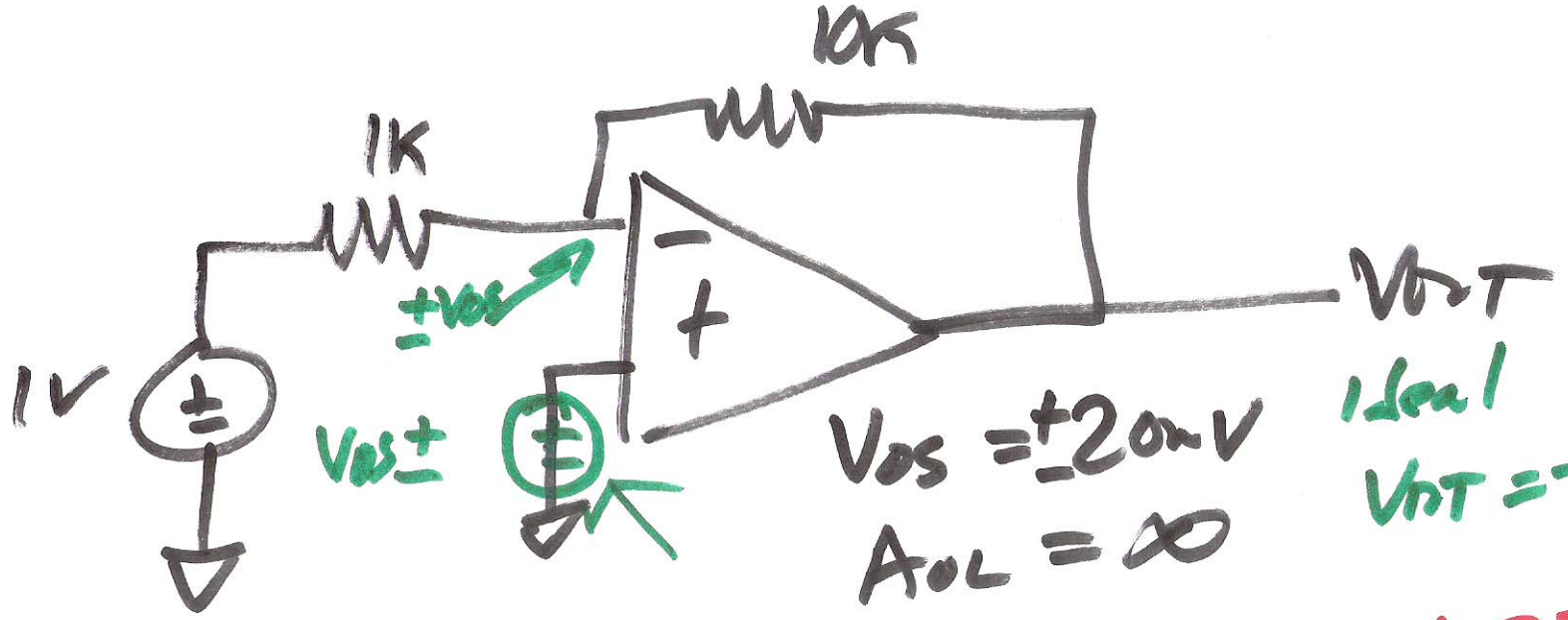
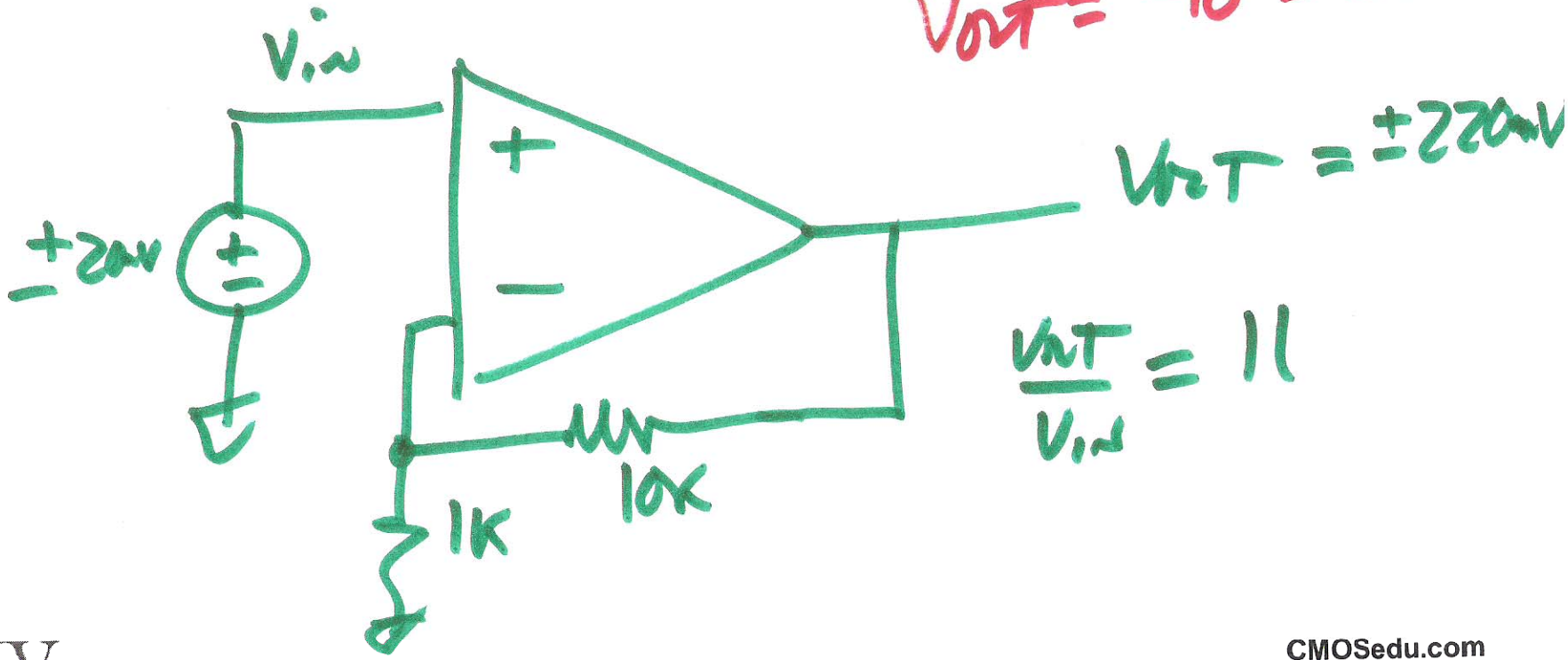
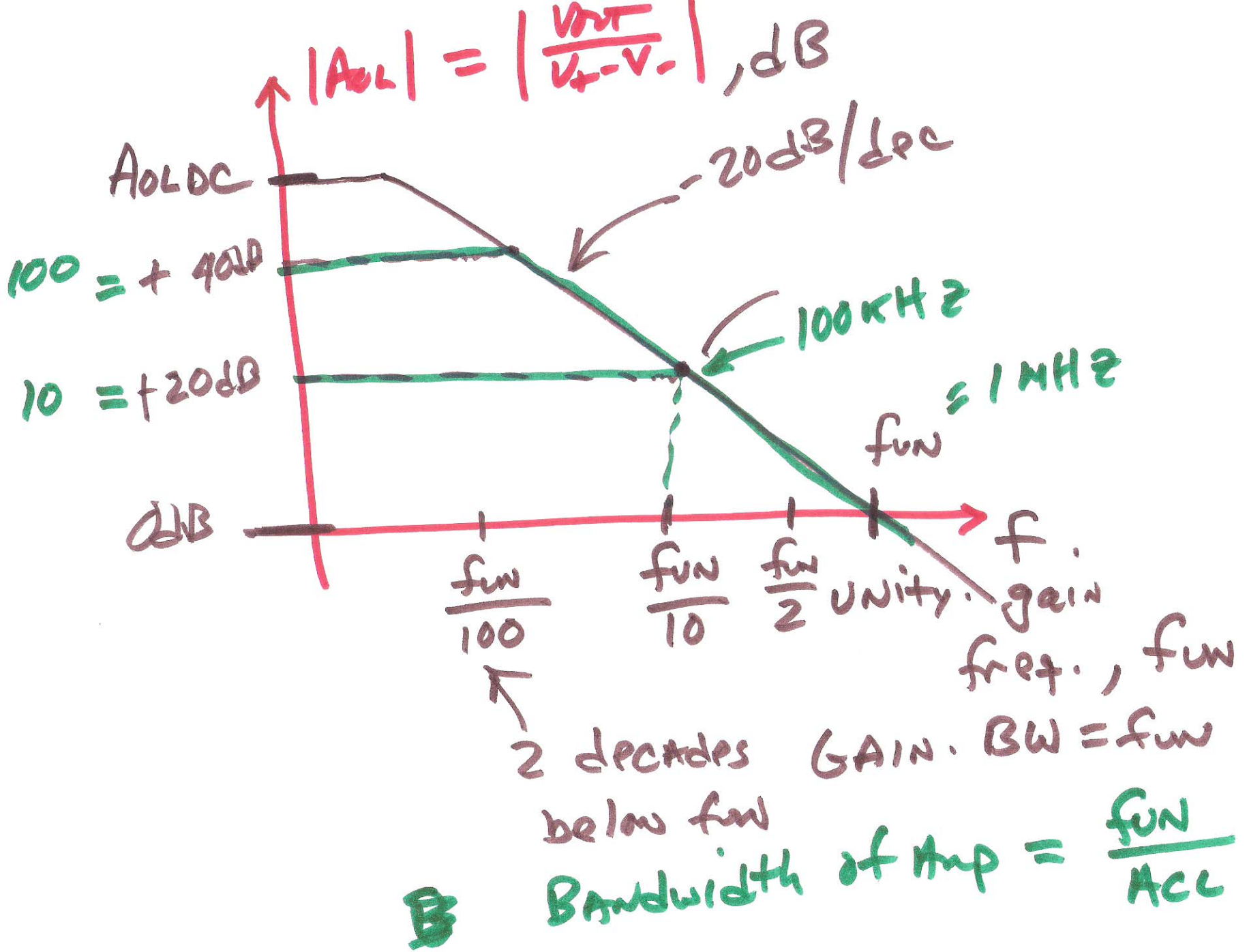
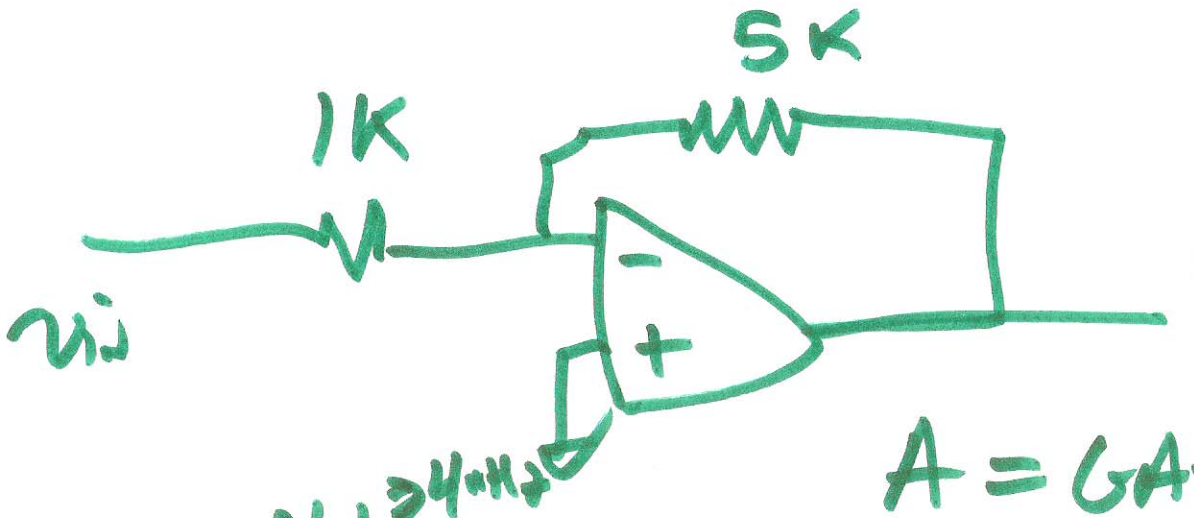


$V_{OUT} = -10 \pm 220mV$



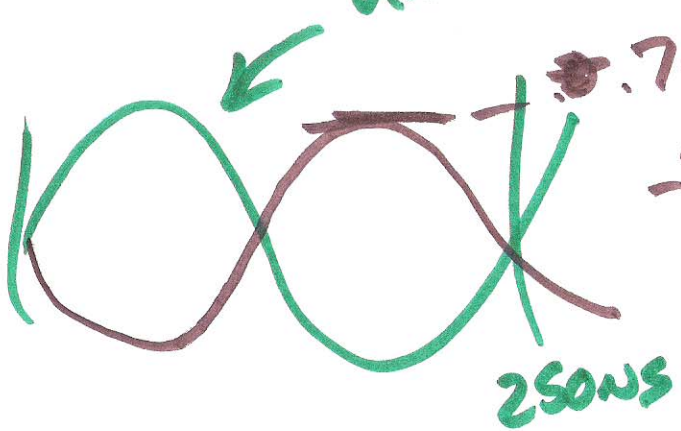

$|A_{CL}| = \left|\frac{V_{out}}{V_+ - V_-}\right|$, dB
A_{OLDC}
100 = + 40dB
10 = +20dB
0dB
-20dB/dec
100KHz
1MHz
f_{UN}
f.
$\frac{f_{UN}}{100}$
$\frac{f_{UN}}{10}$
$\frac{f_{UN}}{2}$
Unity gain freq., f_{UN}
2 decades below f_{UN}
GAIN. BW = f_{UN}
B Bandwidth of Amp = $\frac{f_{UN}}{A_{CL}}$

Op-Amp $f_{UN} = \text{gain} \cdot BW = 20\,MHz$



$A = GAIN = -5$

$|A| = 5$



$$BW|_{CL} = \frac{20\,MHz}{5} = 4\,MHz$$

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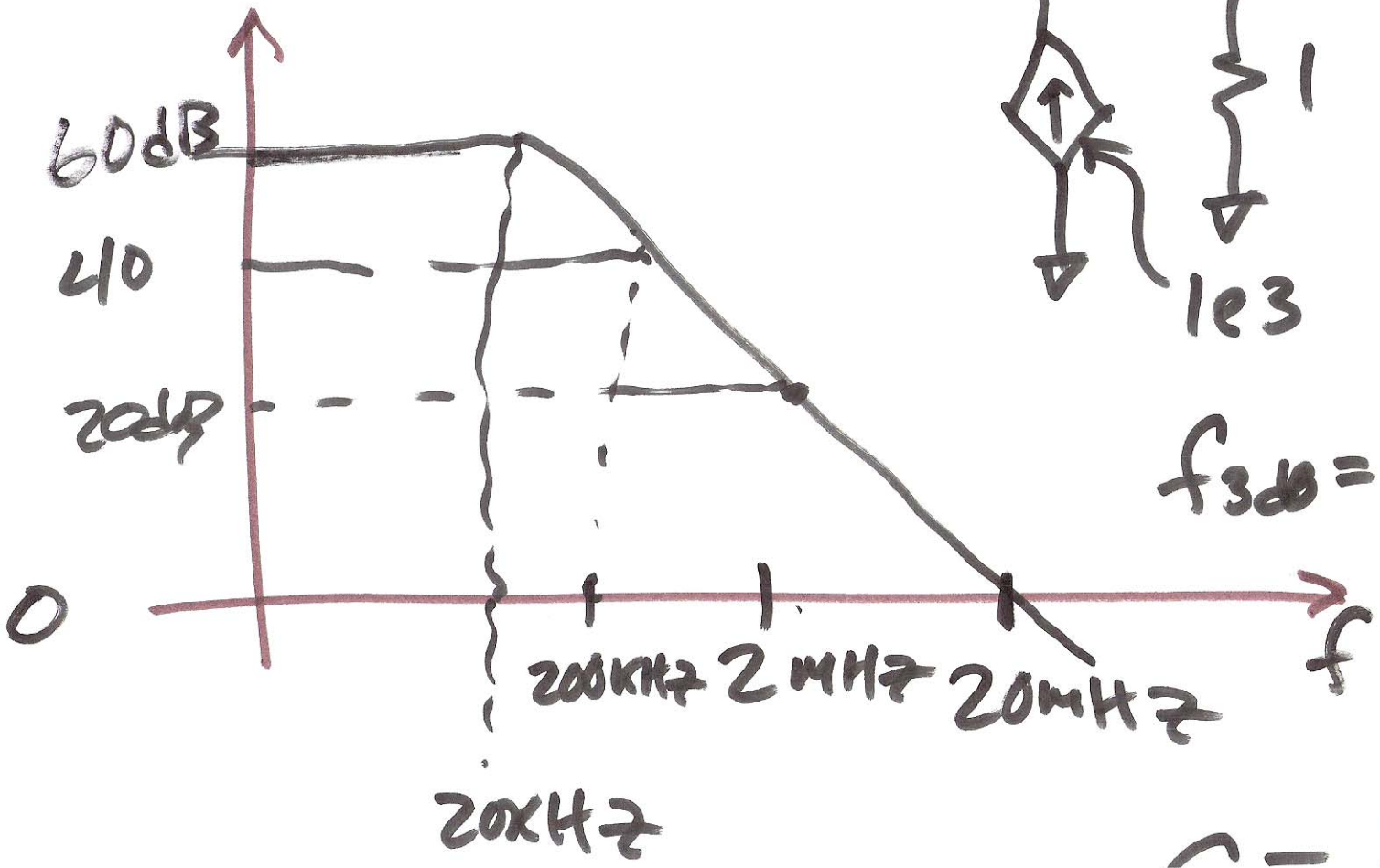
$A_{OL} = 10^3$ GAIN · BW = 20MHz

$20 \log 10^3$



$$f_{3dB} = 20K = \frac{1}{2\pi \cdot 1C}$$

$$C = \frac{1}{2\pi \cdot 20K}$$

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