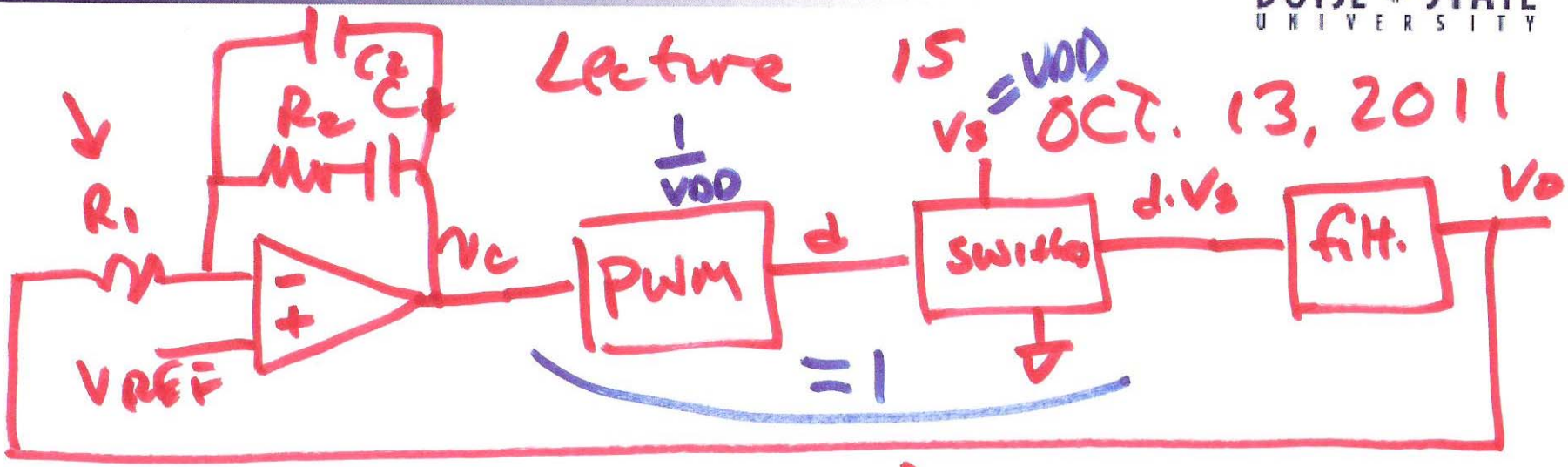
ECE 5/472 Power Electronics

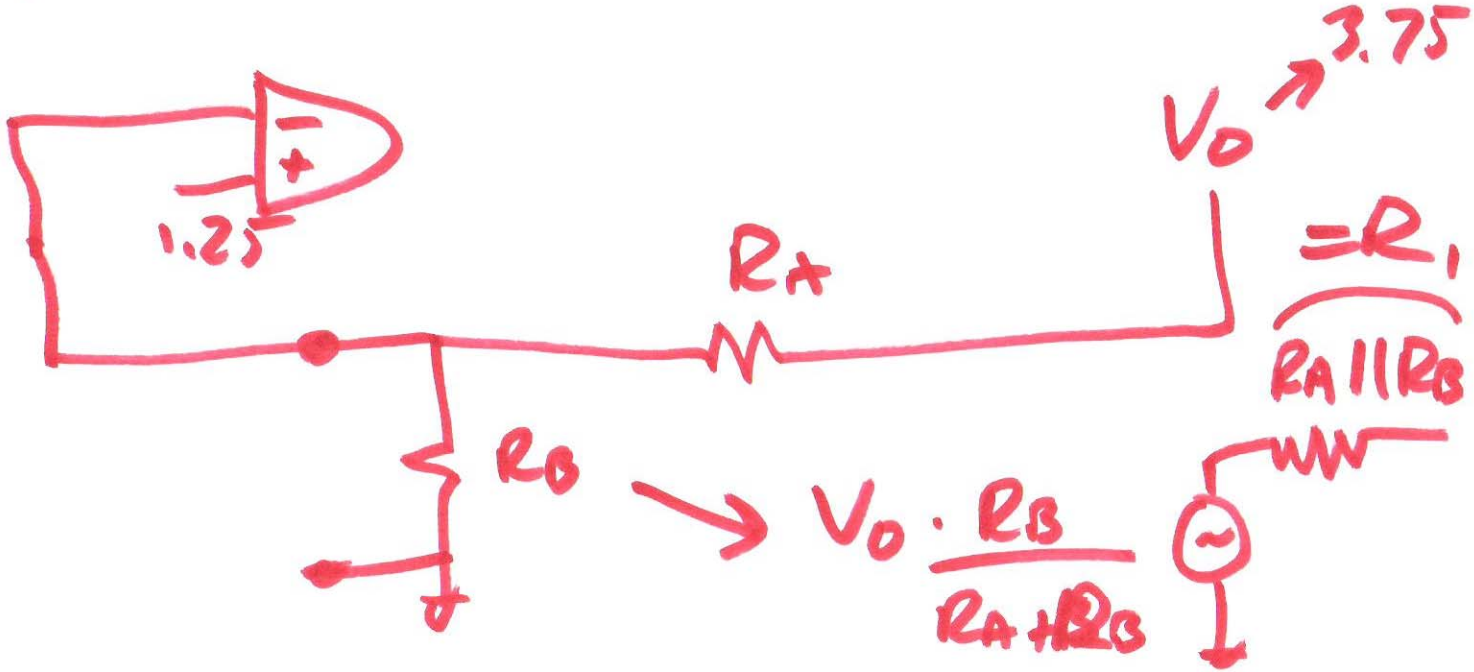
BOISE STATE UNIVERSITY

Lecture 15

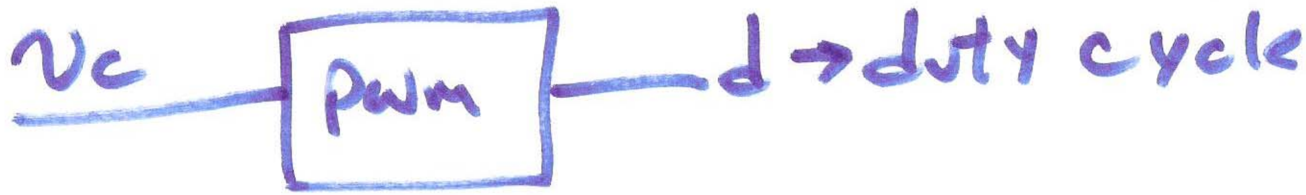
OCT. 13, 2011

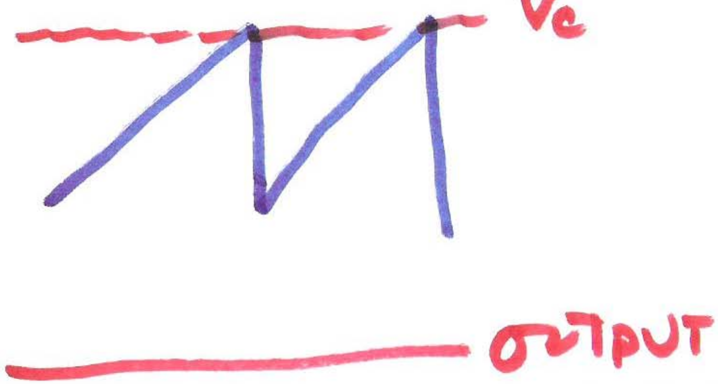


$C_1 >> C_2$ (neglect C_2)



1)





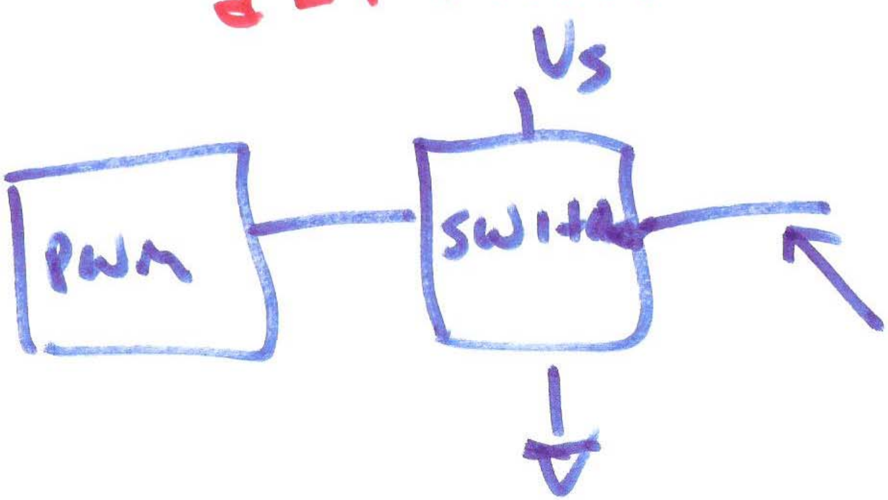
$d = 1 \rightarrow 100\%$

$v_c \rightarrow 0 \quad d = 0$

$v_c \rightarrow VDD \quad d = 1$

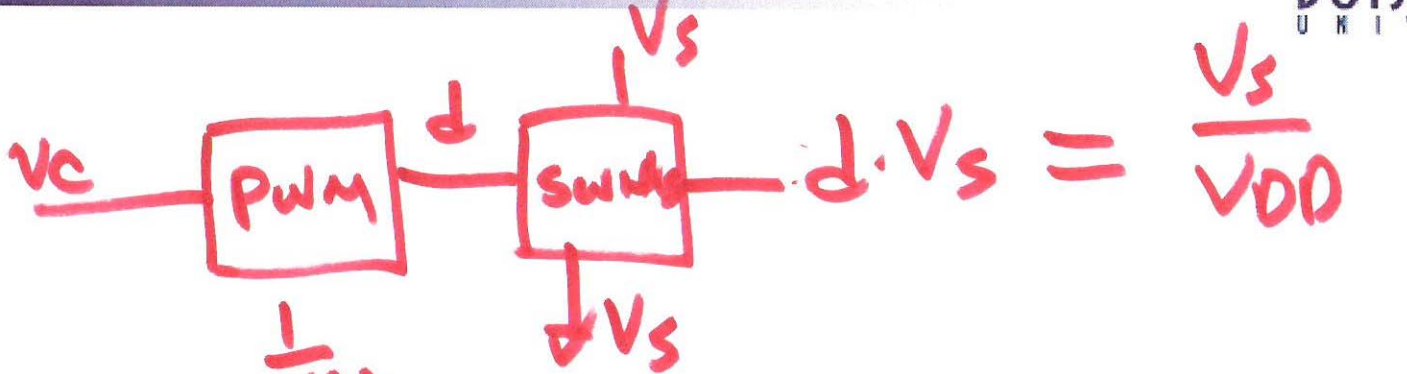
$v_c \cdot GAIN = d$ (with VDD written over v_c, $= 1$ over d, and GAIN pointing to the boxed result)

$$\frac{1}{VDD} = \frac{v_c}{d}$$



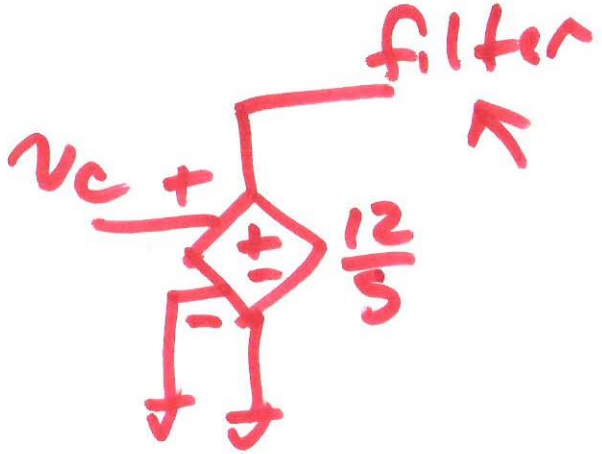
$d \cdot V_s = \text{Average}$

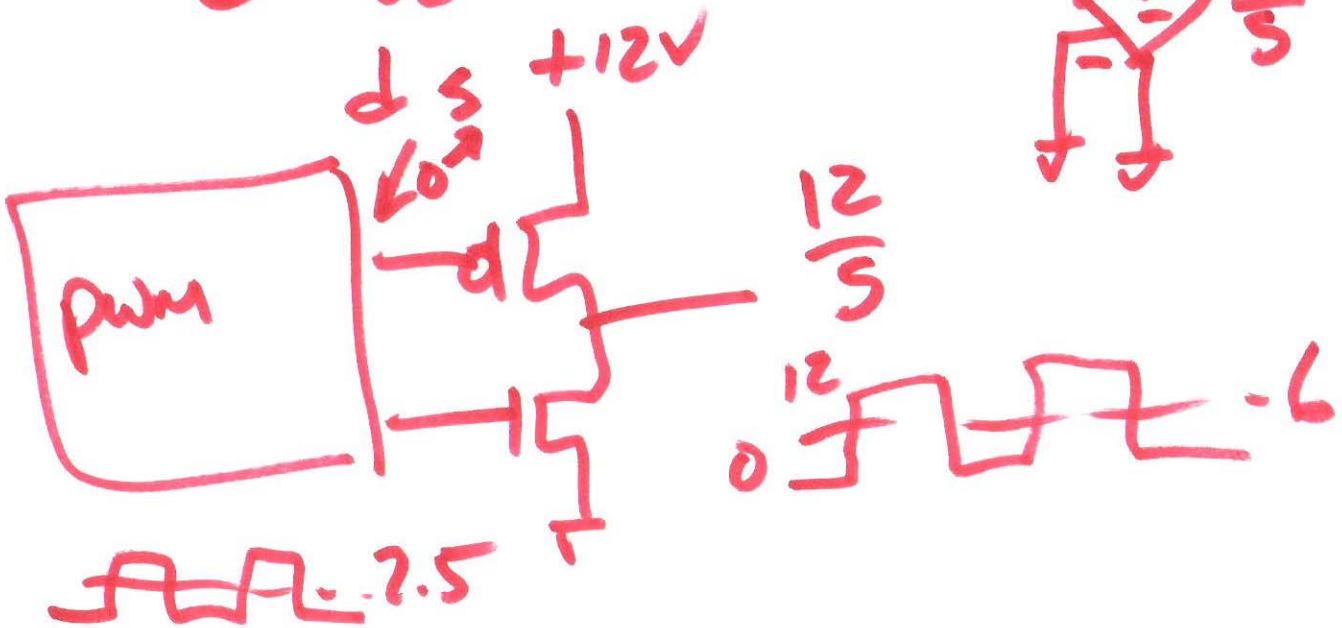
2)

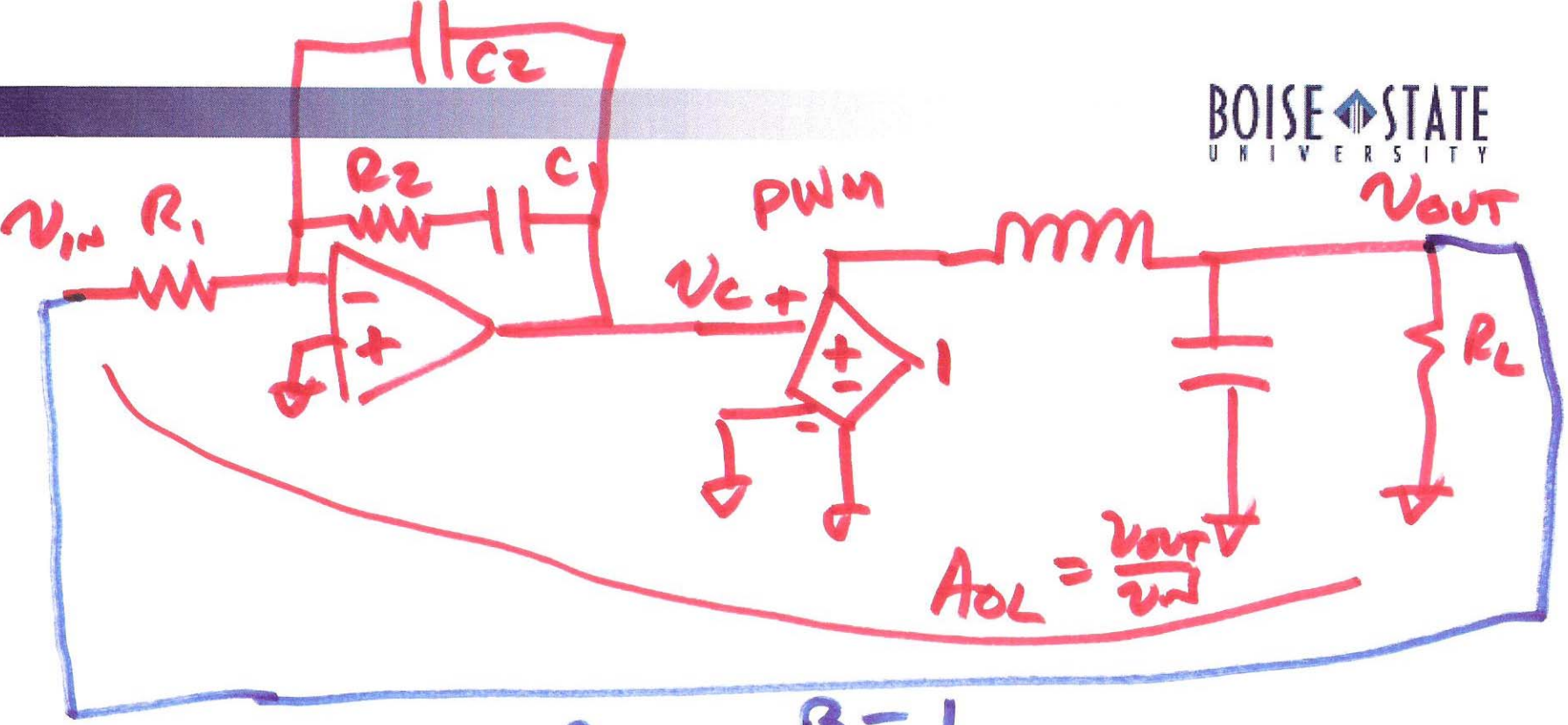


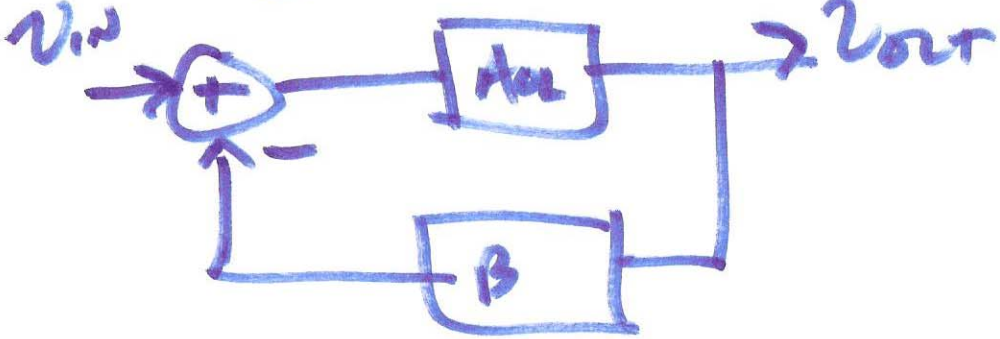
$$d \cdot V_s = \frac{V_s}{V_{DD}}$$

$$\frac{V_c}{2} \frac{d}{V_c} = \frac{1}{V_{DD}}$$









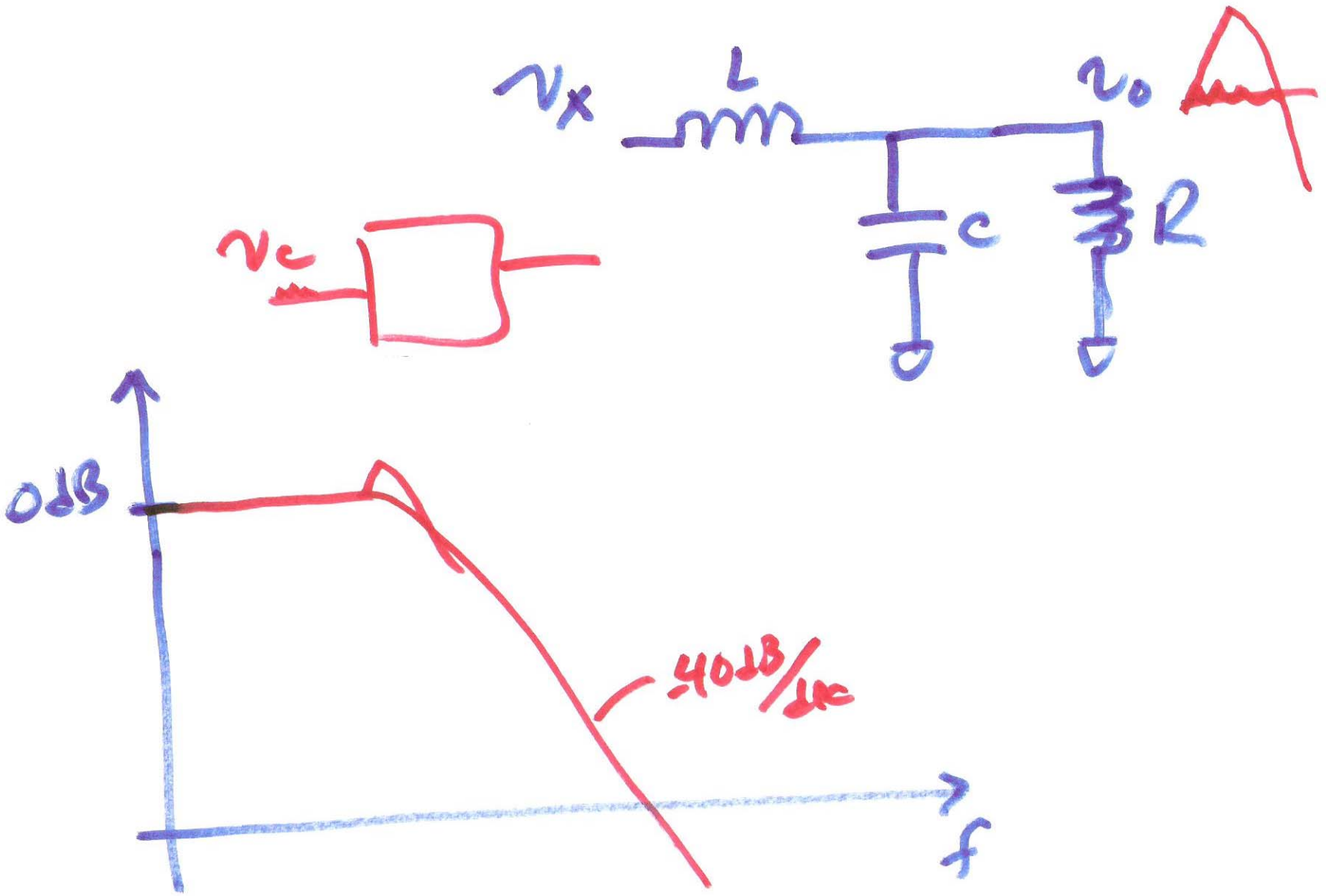
$\beta = 1$

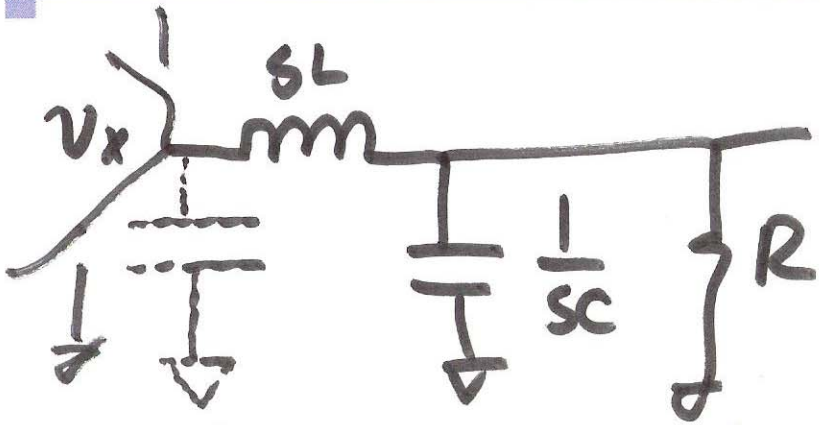
$|\beta A_{OL}| = 1$

$\angle \beta A_{OL} = \pm 180^\circ$

$$\frac{V_{OUT}}{V_{IN}} = \frac{A_{OL}}{1 + \beta A_{OL}} \rightarrow = -1$$

4)

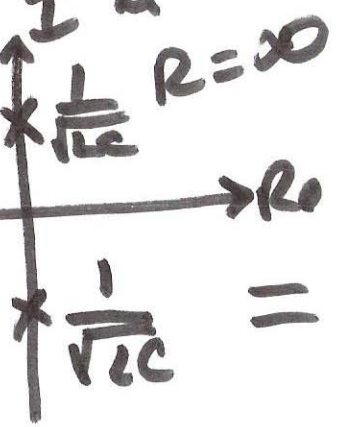

v_x
L
v_o
v_c
C
R
0dB
-40dB/dec
f



$$z_o = \frac{R}{1+sRC}$$

$$\frac{v_x}{v_o} = \frac{\frac{R}{1+sRC}}{\frac{R}{1+sRC} + sL}$$

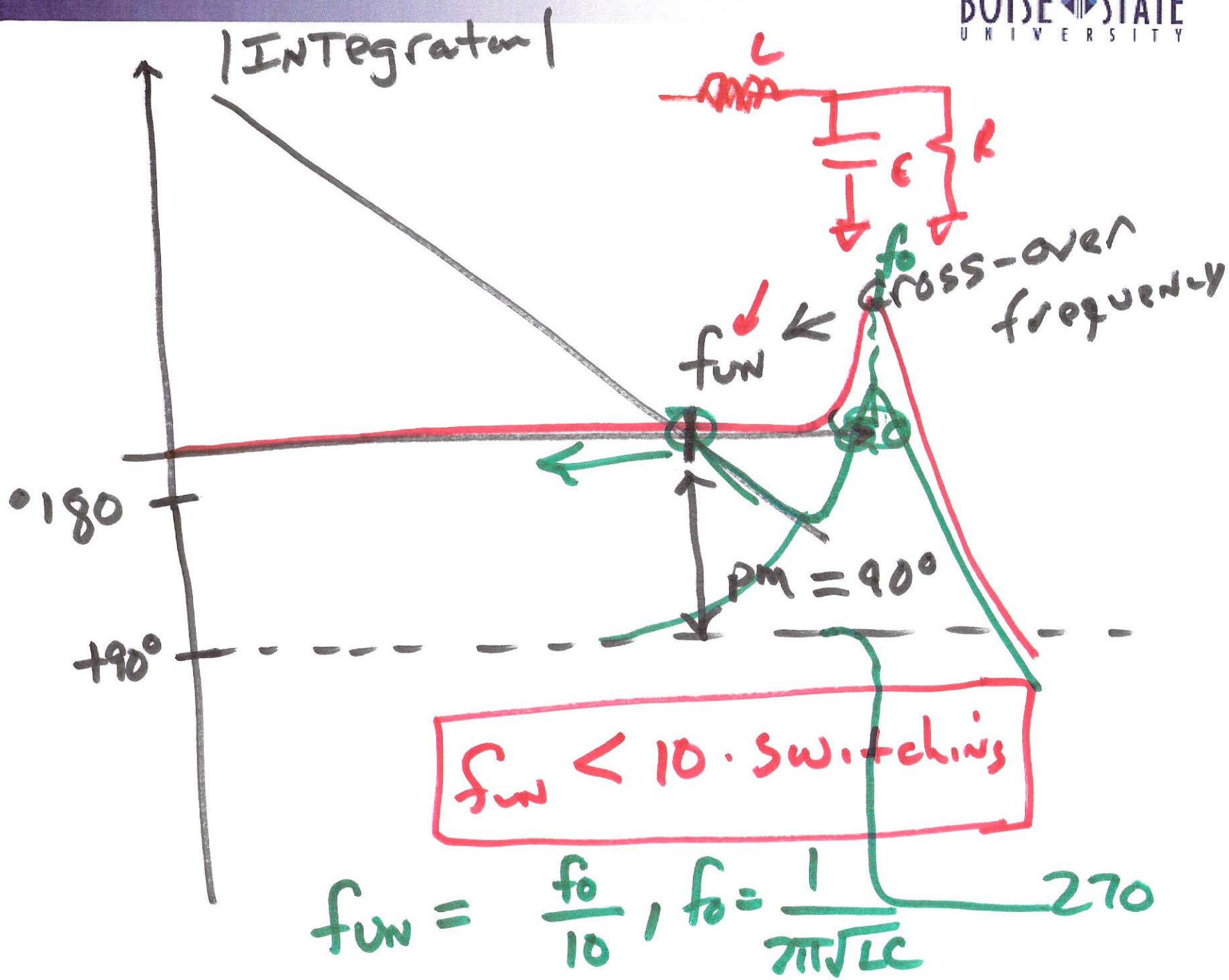
$$p_{1,2} = -\frac{1}{2RC} \pm \frac{\sqrt{\left(\frac{1}{2RC}\right)^2 - 4/LC}}{2}$$

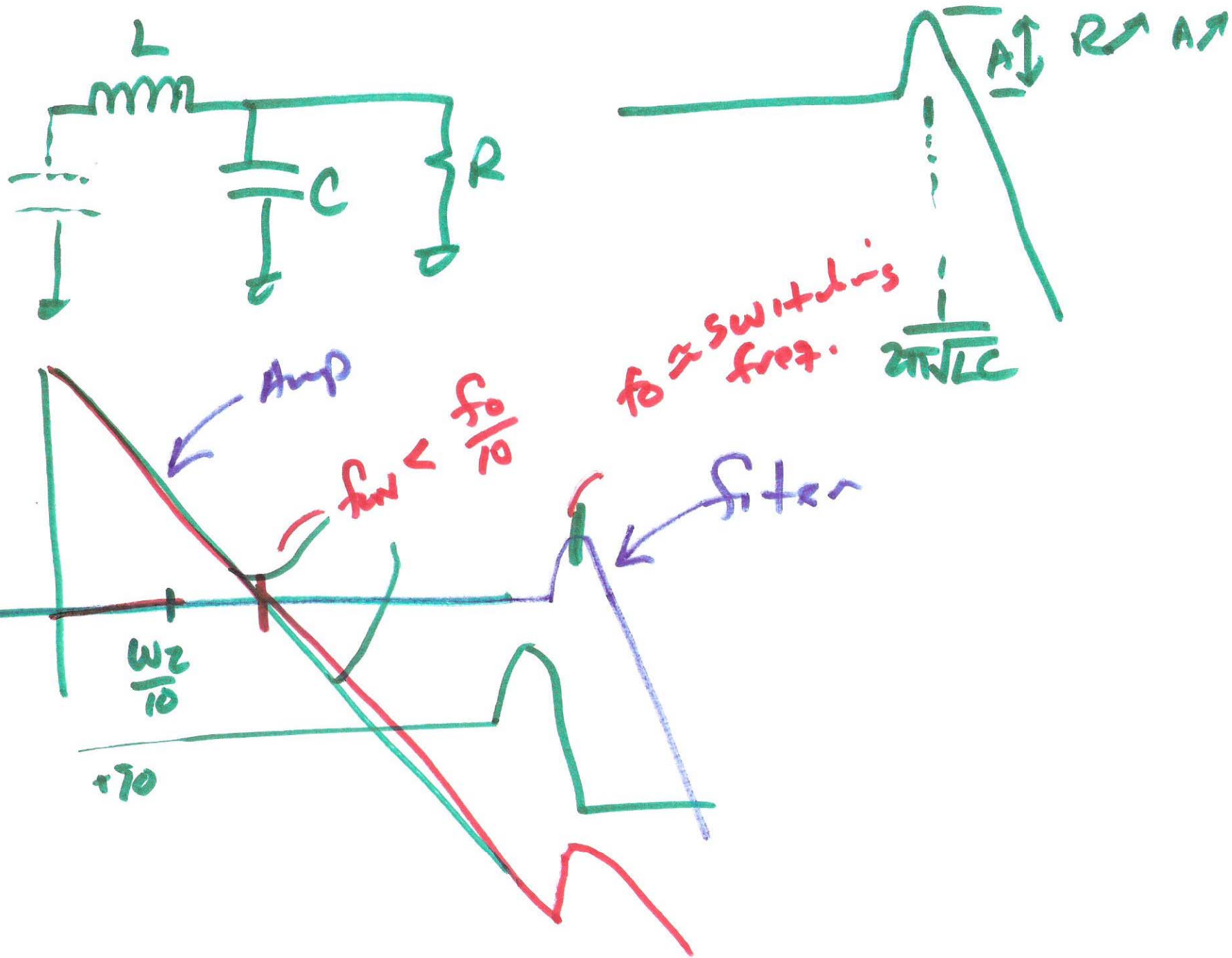


$$= \frac{R}{R + sL + s^2RLC}$$

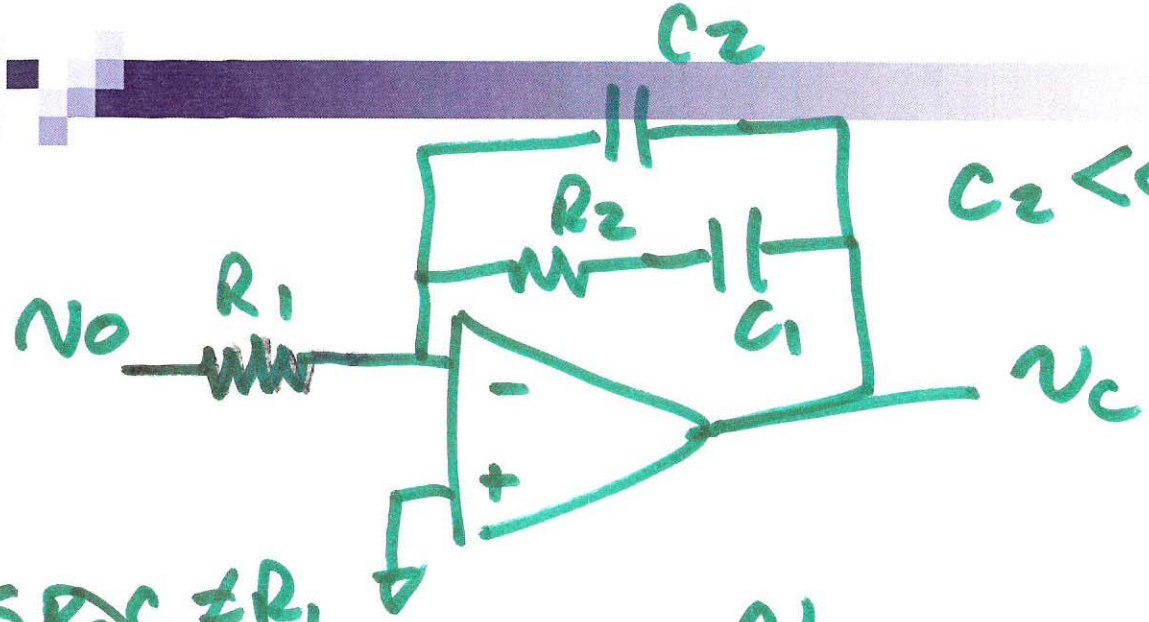
$$= \frac{1}{LC\left(s^2 + s/RC + \frac{1}{LC}\right)}$$

6)


|INTegrator|
L
C
R
f_0
cross-over frequency
f_{UN}
-180
+90°
$PM = 90°$
270
$f_{UN} < 10 \cdot$ switching
$f_{UN} = \frac{f_0}{10}$, $f_0 = \frac{1}{\pi\sqrt{LC}}$



8)



$C_2 \ll C_1$

$$\frac{V_c}{V_o} = -\frac{R_2 + \frac{1}{sC_1}}{R_1} = -\frac{R_2 sC_1 + 1}{R_1 C_1 s}$$

$f_p = 0$

$f_z = \frac{1}{2\pi R_2 C_1}$

$sR_2C \neq R_1$

$j \cdot 2\pi f_z = \frac{R_1}{R_2 C}$

$$-\left(\frac{sR_2C_1 + R_1}{0 + sR_1C_1}\right) = -\left(\frac{R_2}{R_1} + \frac{1}{sR_1C_1}\right)$$

$f_p \to$ at 0 (dc)

$f_z \to \frac{R_1}{2\pi R_2 C_1}$

proportional Integral

ACTIVE PI filter

$f_p = 0$

$$f_z = \frac{1}{2\pi R_2 C_1}$$

$C_2 = \frac{C_1}{10}$

$f_z = 15.9\text{kHz}$

$C_1 = 1\text{nF}$

$R_2 = 1\text{K}$

$R_1 = 1\text{K}$

$$\frac{v_c}{v_x} = \frac{R_2 s C_1 + 1}{R_1 C_1 s + 0} \Rightarrow ? \; 1 = \left| \frac{v_c}{v_x} \right|$$

$$1 = \frac{\sqrt{1^2 + (2\pi f_{un} R_2 C_1)^2}}{\sqrt{0^2 + (2\pi f_{un} R_1 C_1)^2}}$$

$$2\pi f_{UN} R_1 C_1 = \sqrt{1 + (2\pi f_{un} C_1 R_2)^2}$$

R_2

$2\pi f_{un} R_2 C_1 >> 1$