Op-Amp in Negative Feedback

a) $u^+ = u^-$

so, $\boxed{u^+ - u^- = 0}$

b) $\boxed{V_x = V_{out} \frac{R_1}{R_1 + R_2}}$

c) $I_{R_2} = \frac{V_{R_2}}{R_{r2}} = \frac{V_{out} - V_s}{R_2} = \frac{\frac{R_1 + R_2}{R_1} V_s - V_s}{R_2} = \frac{\frac{V_s R_2}{R_1}}{R_2}$

$\boxed{I_{R_2} = \frac{V_s}{R_1}}$

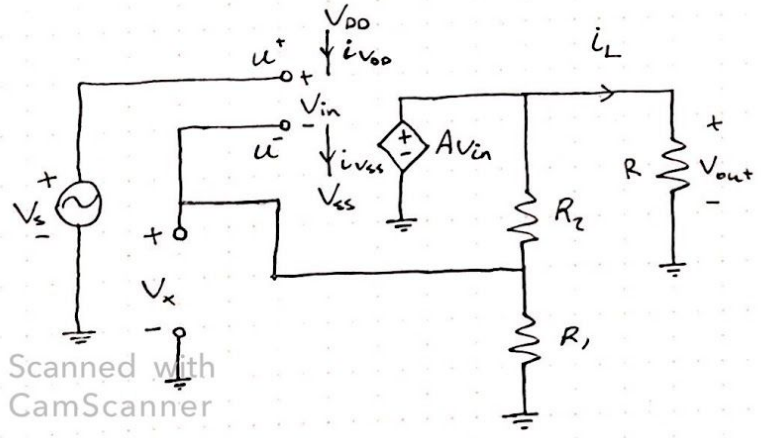
d) $V_s = V_{out} \frac{R_1}{R_1 + R_2}$

$\boxed{V_{out} = \frac{V_s(R_1 + R_2)}{R_1}}$

e) $I_R = \frac{V_R}{R}$

$\boxed{i_L = \frac{V_{out}}{R}}$

f)



g) $V_{out} = AV_{in} = A(u^+ - u^-) = A(V_s - V_x)$

$$V_{out} = A\left(V_s - V_{out}\frac{R_1}{R_1+R_2}\right)$$

$$V_{out} + V_{out}\frac{AR_1}{R_1+R_2} = AV_s$$

$$V_{out}\left(1 + \frac{AR_1}{R_1+R_2}\right) = AV_s$$

$$V_{out} = \frac{AV_s(R_1+R_2)}{AR_1 + R_1 + R_2}$$

$$\lim_{A\to\infty} V_{out} = \lim_{A\to\infty} \frac{V_s(R_1+R_2)}{R_1 + \frac{R_1}{A} + \frac{R_2}{A}}$$

$$\boxed{\lim_{A\to\infty} V_{out} = \frac{V_s(R_1+R_2)}{R_1}}$$

Yes, same as part (d)

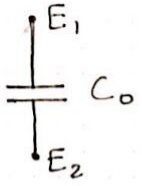
h) $A = \frac{V_{out}}{V_{in}} = \frac{V_{out}}{V_s}$

$$A_{min} = \frac{(1.98)V_s}{V_s}$$

$$\boxed{A_{min} = 1.98}$$

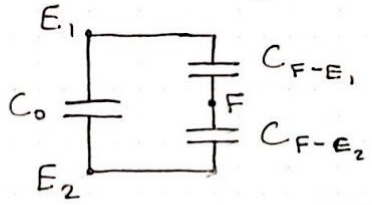
2. Capacitive Touchscreen

a) without finger:



$$C_0 = \varepsilon \frac{A}{d} = \boxed{\varepsilon \frac{d_2 w_1}{t_1}}$$

with finger:



$$C_{F-E_1} = \varepsilon \frac{A}{d} = \boxed{\varepsilon \frac{w_1 d_1}{t_2 - t_1}}$$

$$C_{F-E_2} = \boxed{\varepsilon \frac{w_2 d_2}{t_2}}$$

b) $C_0 = (4.43 \times 10^{-11} \frac{F}{m}) \frac{(0.001m)(0.001m)}{0.001m} = \boxed{4.43 \times 10^{-14} F}$

$C_{F-E_1} = (4.43 \times 10^{-11} \frac{F}{m}) \frac{(0.001m)(0.01m)}{0.001m} = \boxed{4.43 \times 10^{-13} F}$

$C_{F-E_2} = (4.43 \times 10^{-11} \frac{F}{m}) \frac{(0.002m)(0.001m)}{0.002m} = \boxed{4.43 \times 10^{-14} F}$

c) with finger: $C_F = C_0 + \frac{(C_{F-E_1})(C_{F-E_2})}{C_{F-E_1} + C_{F-E_2}}$

$$\text{Difference} = C_F - C_0 = \frac{C_{F-E_1} C_{F-E_2}}{C_{F-E_1} + C_{F-E_2}} = \boxed{4.03 \times 10^{-14} F}$$

3. Homework Process

I worked on this homework alone. I read the notes last week, so I was able to do this homework.