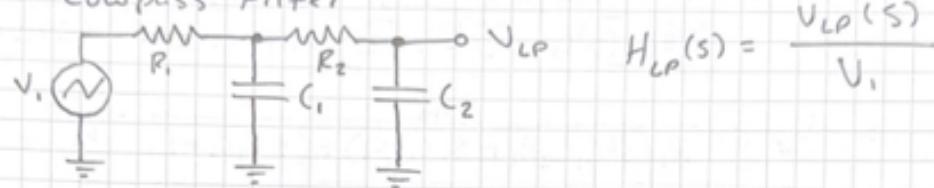


PRE-LAB 2

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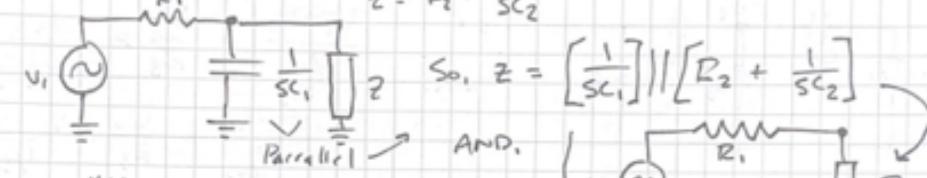
① Lowpass Filter



- $V_1(t) \leftrightarrow V_1(s)$
- $V_{LP}(t) \leftrightarrow V_{LP}(s)$
- $C_1 \leftrightarrow 1/SC_1$ AND "C2"

COMBINE $R_2 \parallel C_2$

$$Z = R_2 + \frac{1}{SC_2}$$



$$Z = \frac{X_1 Y}{X_1 + Y} \Rightarrow \left[\frac{1}{SC_1} \right] \left[R_2 + \frac{1}{SC_2} \right]$$

$$\left[\frac{1}{SC_1} \right] + \left[R_2 + \frac{1}{SC_2} \right]$$

Plug into Simplification Calculator

$$Z = \frac{sR_2C_2 + 1}{s^2C_1C_2R_2 + SC_1 + SC_2}$$

Voltage Divider so,

$$I = \frac{V_1}{R_1 + Z}$$

$$I = \frac{1/SC_1}{(1/SC_1)(R_2 + 1/SC_2)} I$$

Plug in for Z:

$$I = \frac{V_1}{R_1 + \frac{sR_2C_2 + 1}{s^2C_1C_2R_2 + SC_1 + SC_2}} \Rightarrow \frac{V_1(s^2C_1C_2R_2 + SC_1 + SC_2)}{R_1(s^2C_1C_2R_2 + S(C_1 + C_2) + (sR_2C_2 + 1))}$$

$$I_1 = \frac{1/SC_1 \cdot SC_1}{(1/SC_1)(R_2 + 1/SC_2) \cdot SC_1 \cdot \frac{SC_2}{1}} \stackrel{I \rightarrow 1}{\Rightarrow} I_1 = \frac{I SC_2}{s^2C_1C_2R_2 + SC_1 + SC_2}$$

Now finding V_{LP}

JOAQUIN SALAS

731000141

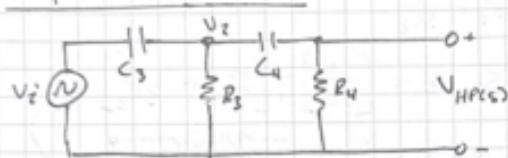
$$V_{LP} = I_1 \cdot \frac{1}{SC_2} \quad \text{Plug into this}$$

$$= \frac{1}{SC_2} \left[\frac{SC_2}{(S^2C_1C_2R_2 + SC_1 + SC_2)} \right] \left[\frac{V_i(S^2C_1C_2R_2) + S(C_1 + C_2)}{R_1(S^2C_1C_2R_2 + SC_1 + C_2) + (SR_2(C_2 + 1))} \right]$$

$$\rightarrow V_{LP} = \frac{V_{i0}}{R_1(S^2C_1C_2R_2 + SC_1 + C_2) + (SR_2(C_2 + 1))} \cdot \frac{1}{V_i}$$

$$\rightarrow \boxed{\frac{V_{LP}}{V_i} = \frac{1}{R_1(S^2C_1C_2R_2 + SC_1 + C_2) + (SR_2(C_2 + 1))}}$$

High Pass Filter



$$\frac{V_{i0}}{R_3} + \frac{V_o}{R_3} = \frac{V_o}{R_4} + \frac{V_o - V_{HP}}{SC_4}$$

$$\frac{V_i - V_o}{1/C_3s} = \frac{V_o}{R_3} + \frac{V_o - V_{HP}}{1/SC_4s}$$

$$V_{HP} = V_i \cdot \frac{R_4 V}{(\frac{1}{SC_4} + R_4)}$$

$$\rightarrow V = \frac{V_{HP}(R_4SC_4 + 1)}{R_4SC_4}$$

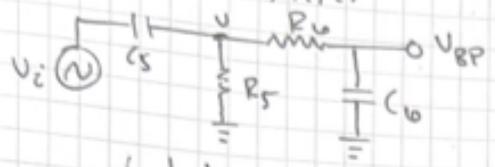
$$SC_3 \left[\frac{V_{HP}(R_4SC_4 + 1)}{SC_4R_4C_4s} - V_i \right] + \frac{V_{HP}(1 + SR_4C_4)}{R_3R_4C_4s} + SC_4 \left[\frac{V_{HP}(1 + SR_4C_4)}{SR_4C_4} - V_{HP} \right] = 0$$

$$\rightarrow \frac{SC_3}{SR_4C_4} \left[V_{HP}[SR_4C_4 + 1] - [SR_4C_4V_i] \right] + \frac{V_{HP}(R_4C_4s + 1)}{SR_3R_4C_4} + \frac{SR_4}{SR_4C_4} \left[V_{HP}(R_4C_4s + 1) - (R_4C_4V_{HP}s) \right] = 0$$

$$\rightarrow V_{HP} \left[S^2C_3R_3R_4C_4 + SC_3R_3 + SC_4R_4 + SC_4R_3 + 1 \right] = \frac{S^2C_3R_3R_4C_4V_i}{V_i}$$

$$\rightarrow \frac{V_{HP}(s)}{V_i} = \frac{S^2C_3R_3R_4C_4}{S^2C_3R_3R_4C_4 + SC_3R_3 + SC_4R_4 + SC_4R_3 + 1}$$

(C) BandPass Filter



JOAQUIN SALAS 731000141

$$. \frac{SC_5}{R_5} \cdot \frac{V - V_i}{SC_5} + \frac{V}{R_5} + \frac{V - V_{BP}}{R_6} = 0, \quad \text{Eqn 1}$$

$$SC_5 [V - V_i] + \frac{V}{R_5} + \frac{V - V_{BP}}{R_6} = 0$$

$$V_{BP} = \frac{\left(\frac{1}{SC_6}\right)V}{\left[R_6 + \frac{1}{SC_6}\right] \cdot SC_5} \rightarrow V = V_{BP} \left(1 + SC_6 R_6\right)$$

Plug Back in.

$$0 = SC_5 [V_{BP} (SC_6 R_6 + 1) - V_i] + \left[\frac{V_{BP} (SC_6 R_6 + 1)}{R_5} \right] + \frac{V_{BP} (SC_6 R_6 + 1) - V_{BP}}{R_6}$$

$$0 = \left[SC_5 [V_{BP} (SC_6 R_6 + 1) - V_i] + \frac{V_{BP}}{R_5} (SC_6 R_6 + 1) + \frac{1}{R_6} (V_{BP} SC_6 R_6) \right] \cancel{R_3}$$

$$\rightarrow V_{BP} \left[S^2 C_5 R_5 C_6 R_6 + SC_5 R_5 + SC_6 R_6 + 1 + SC_6 R_5 \right] = SC_5 R_5 V_i$$

$$\rightarrow \frac{V_{BP}(s)}{V_i(s)} = \frac{SC_5 R_5}{S^2 C_5 R_5 C_6 R_6 + SC_5 R_5 + SC_6 R_6 + 1 + SC_6 R_5 + 1}$$

(2) (a)

$$H(s) = \frac{1}{1 + \frac{S}{2\pi f_1} \cdot \frac{2\pi f_1}{s}} \rightarrow \frac{\frac{2\pi f_1}{s}}{\frac{2\pi f_1 R_0}{s} + R_0}$$

$$R = R_1, C_1 = \frac{1}{2\pi f_1 R_1} \quad f_1 = 1000 \text{ Hz} = \frac{1}{2\pi R_1 C_1} \rightarrow R_1 C_1 = \frac{1}{2\pi (1000)}$$

$$R = R_1 = R_2, C_2 = \frac{1}{2\pi f_2 R_2} \quad R_1 = 1600 \Omega, C_1 = 0.1 \mu\text{F} = 1.6 \times 10^{-6} \text{ sec.}$$

$$f_2 = 10000 \text{ Hz} = \frac{1}{2\pi C_2 R_2} \rightarrow R_2 C_2 = \frac{1}{2\pi (10000)} = 1.6 \times 10^{-5} \text{ sec}$$

$$\underline{R_2 = 1600 \Omega, C_2 = 1 \mu\text{F}}$$

$$(b) 2\pi f_3 = \frac{1}{R_3 C_3} \rightarrow R_3 C_3 = \frac{1}{2\pi f_3} \quad f_3 = 1000 \text{ Hz}$$

$$2\pi f_4 = \frac{1}{R_4 C_4} \rightarrow R_4 C_4 = \frac{1}{2\pi f_4} = 1.6 \times 10^{-4} \text{ sec} \\ = 1.6 \times 10^{-4} \text{ sec}$$

$$C_3 = C_4 = 1 \mu\text{F}$$

$$R_3 = 160 \text{ ohms}$$

$$R_4 = 16 \text{ ohms}$$

(c) $C_5 = C_6 = 1 \mu\text{F}$

$$R_5 = 160 \text{ ohms}$$

$$R_6 = 16 \text{ ohms}$$

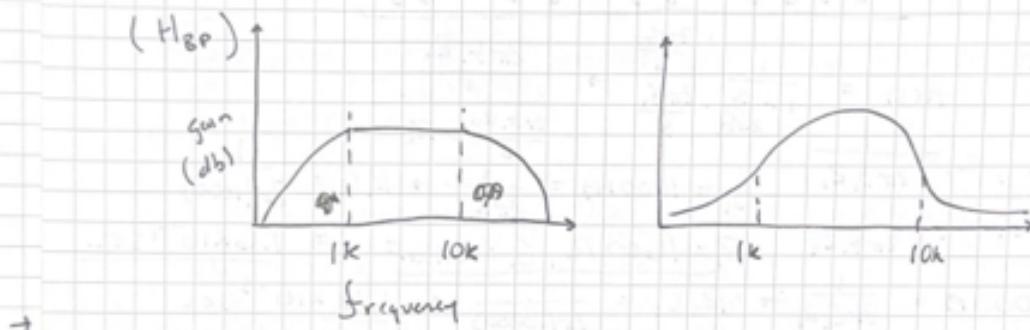
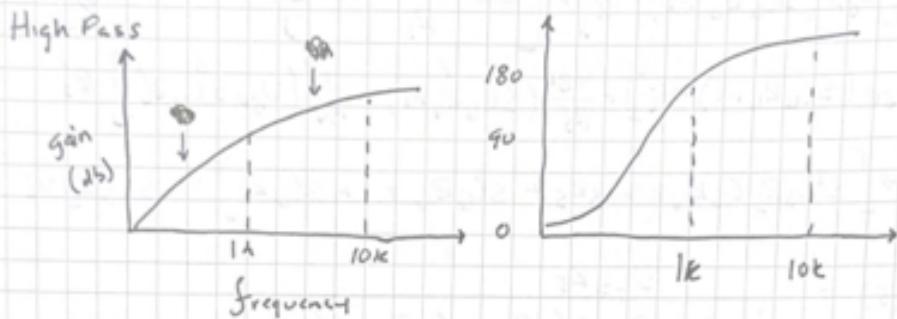
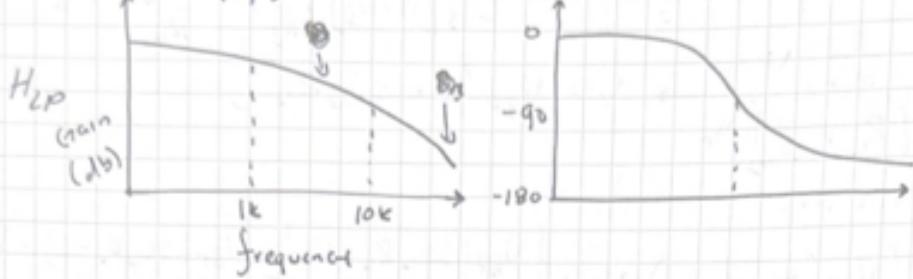
3. Magnitude and Bode Plots

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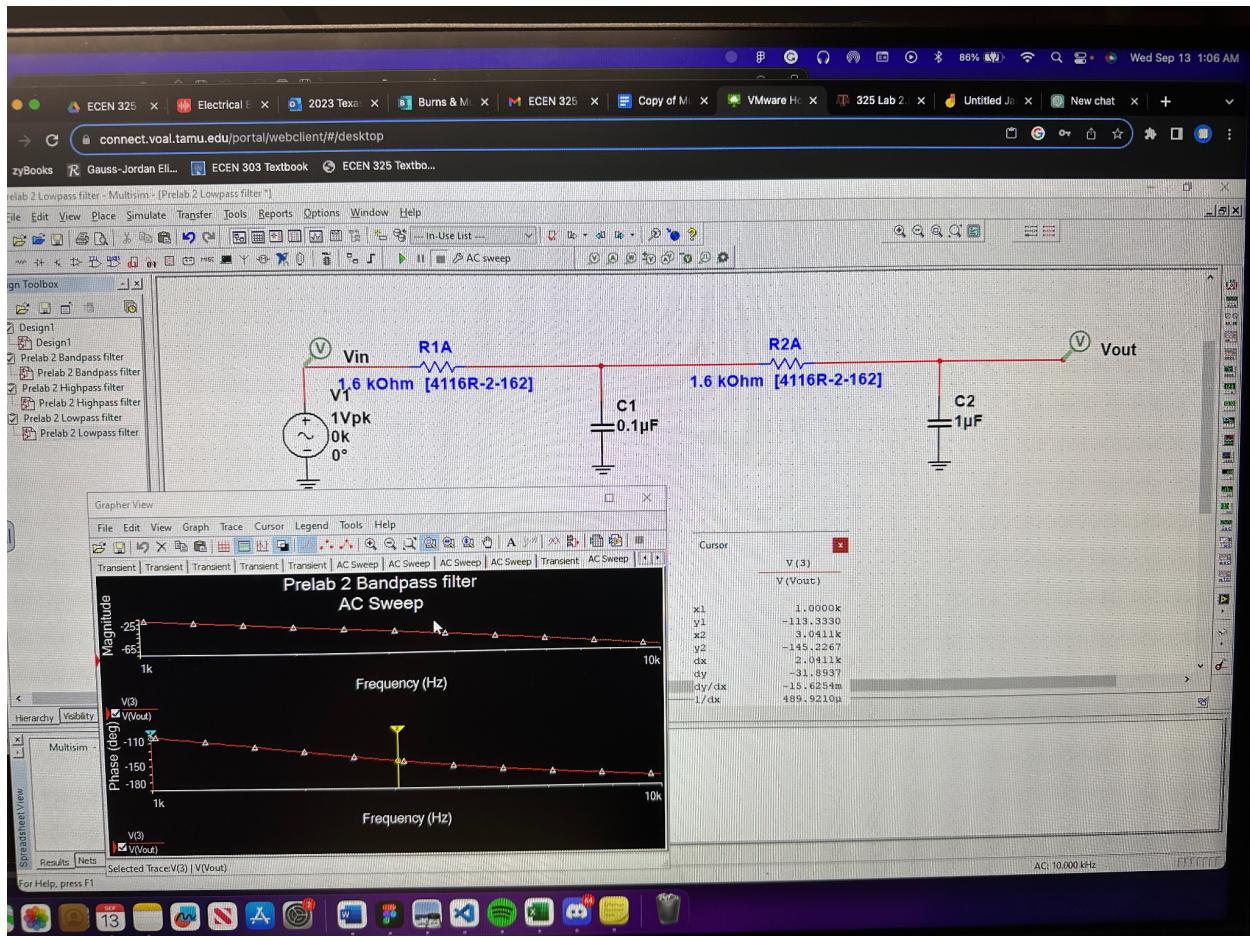
$$\omega = 2\pi f \Rightarrow f_1, f_2, f_3 = 1000 \text{ Hz}$$

$$\omega_{1,2,3} = 6283$$

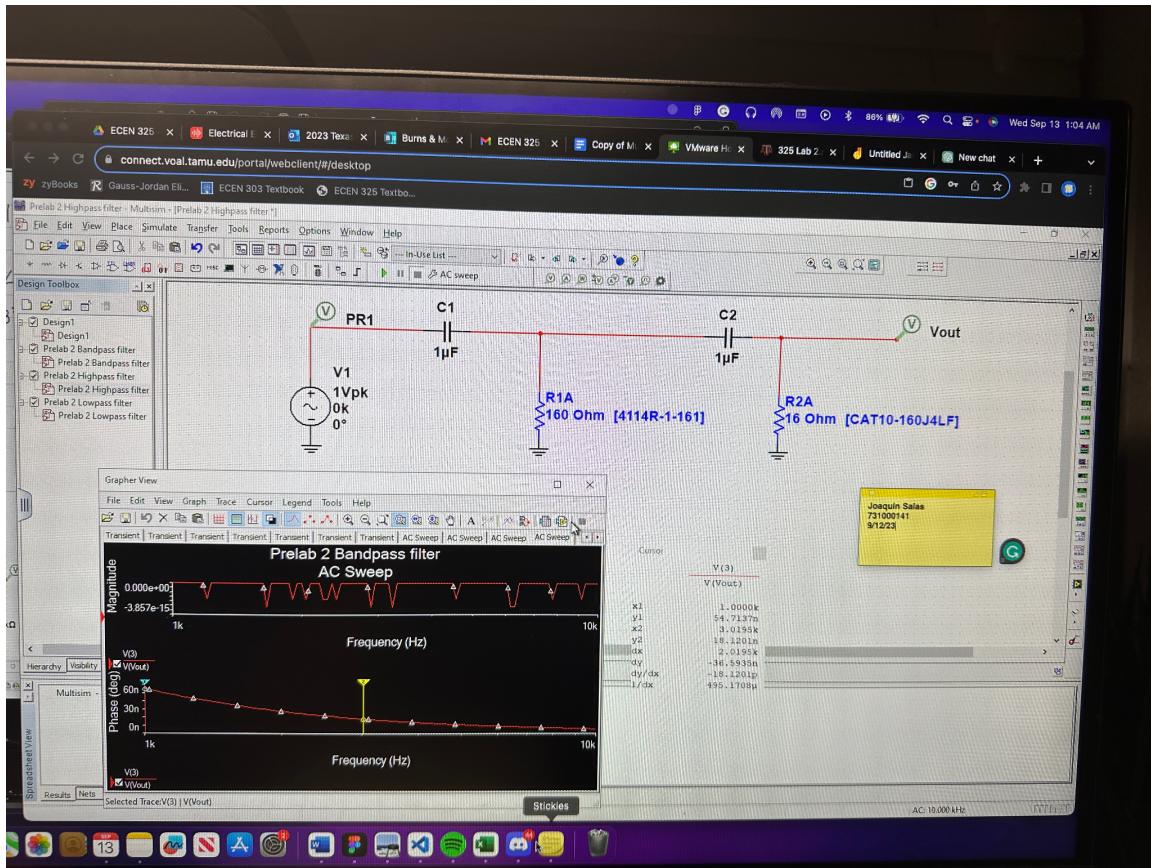


Simulation

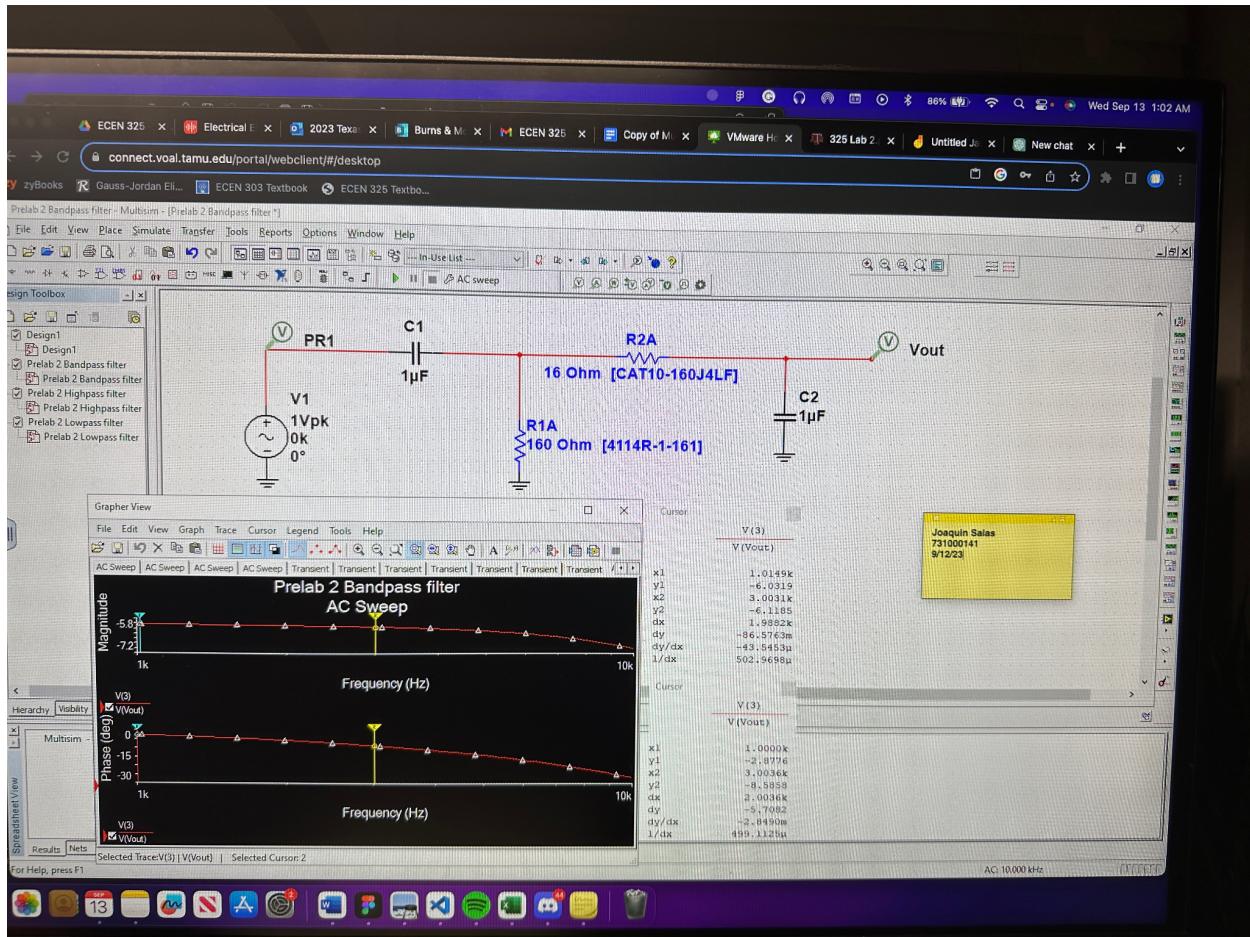
1) Lowpass Filter 3dB



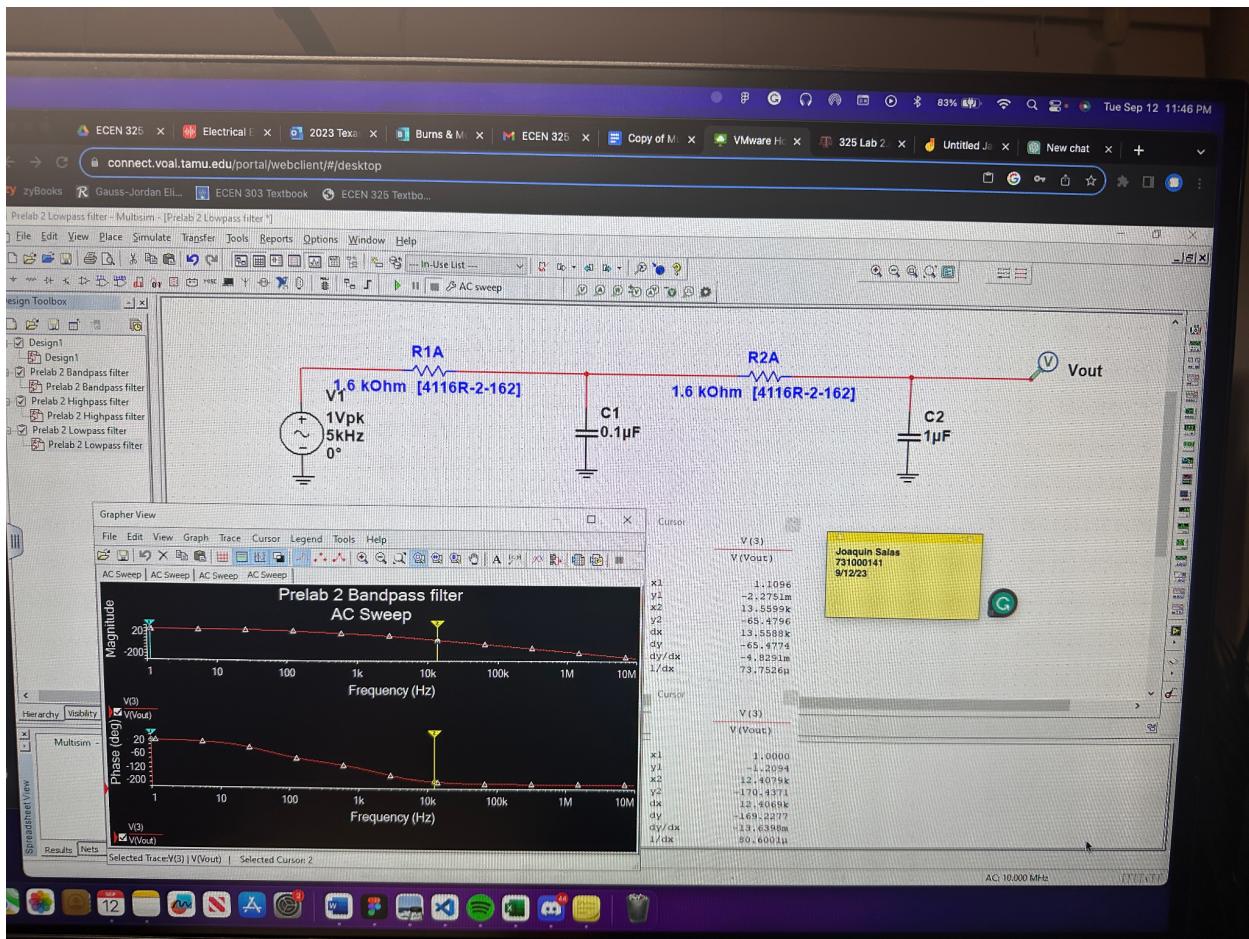
2) Highpass Filter 3dB



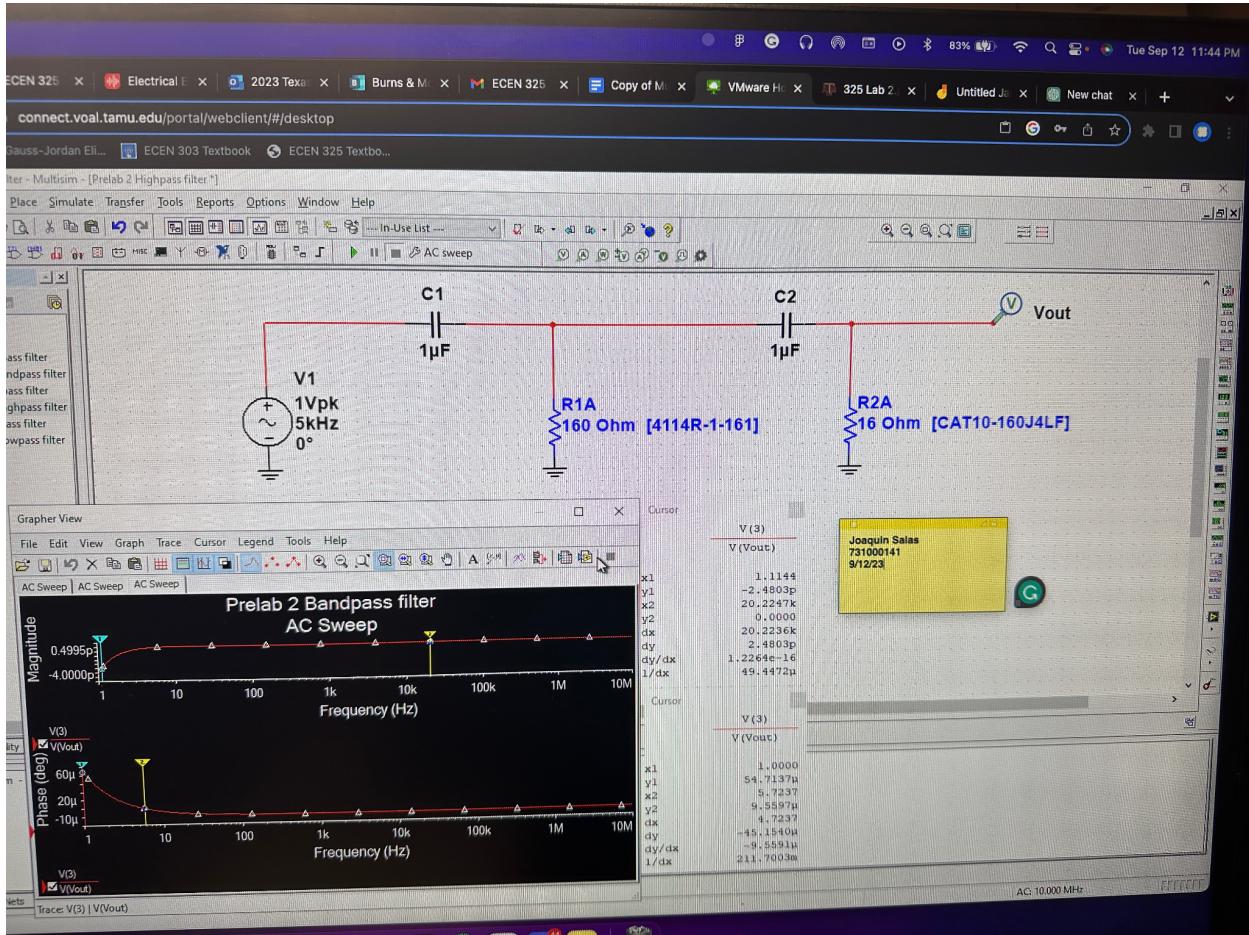
3) Bandpass Filter 3dB



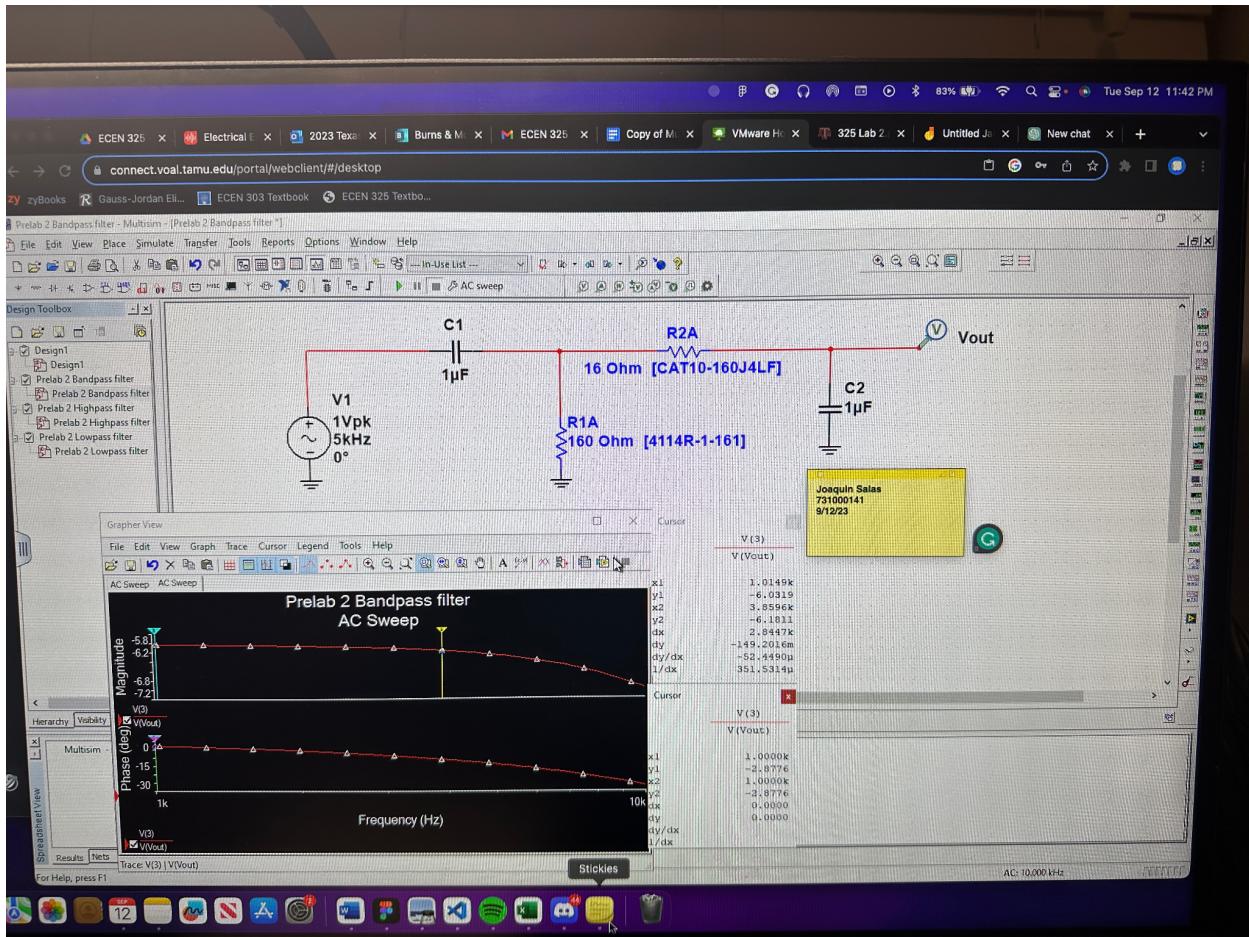
4) Low Pass @5kHz



5) High Pass @5kHz

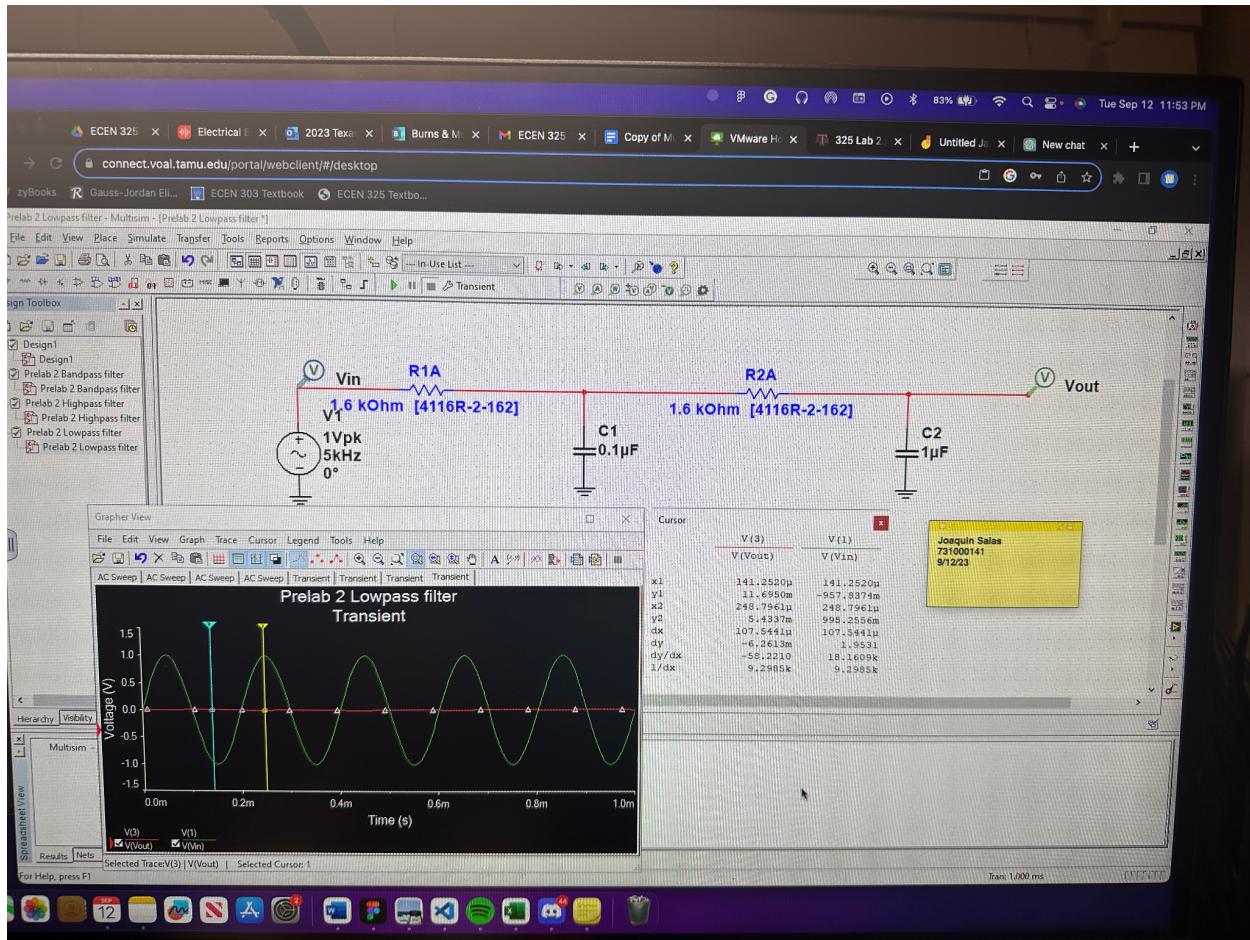


6) Bandpass @5kHz

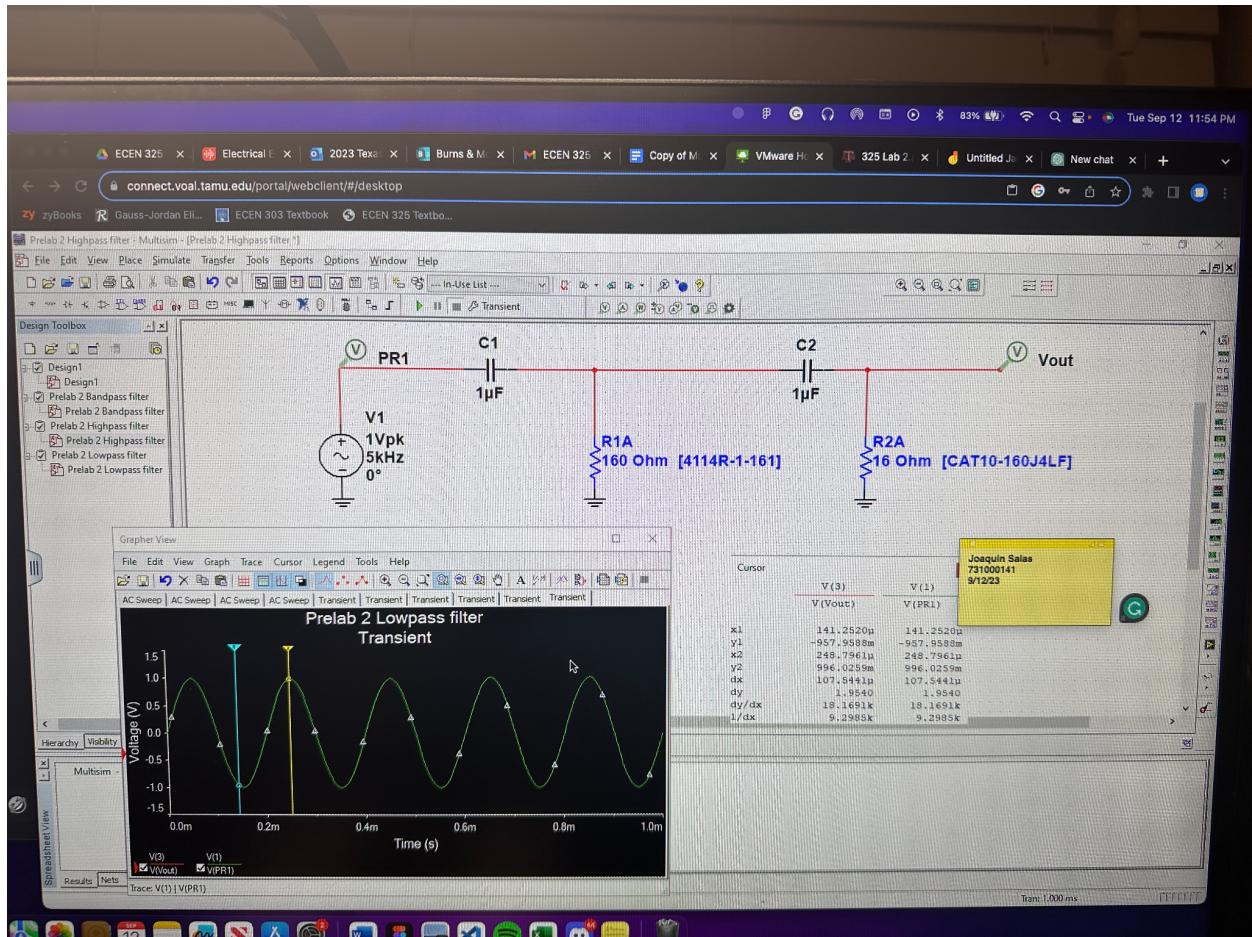


Question 2

a) Lowpass Transient



b) High pass transient



c) Bandpass transient

