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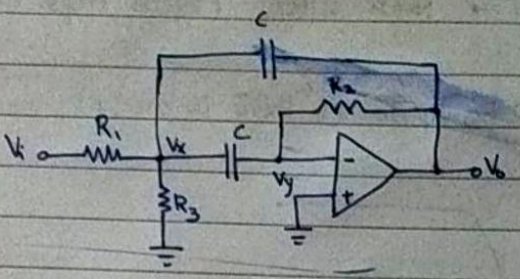
EE18B104

EE2019 - Analog Systems & Lab
Prelab 6 - BANDPASS FILTER



$$\frac{V_x - V_i}{R_1} + \frac{V_x}{R_3} + (V_x - V_o)sC + (V_x - 0)sC = 0$$

$$V_x\left(\frac{1}{R_1} + \frac{1}{R_3} + 2sC\right) = \frac{V_i}{R_1} + V_o sC \quad \rightarrow (i)$$

$$(0 - V_x)sC + \frac{(0 - V_o)}{R_2} = 0$$

$$V_o = -V_x sCR_2$$

$$-\frac{V_o}{sCR_2}\left[\frac{1}{R_1} + \frac{1}{R_3} + 2sC\right] - V_o \cdot sC = \frac{V_i}{R_1}$$

$$-V_o\left[\frac{s^2C^2R_2 + \left(\frac{1}{R_1} + \frac{1}{R_3} + 2sC\right)}{sCR_2}\right] = \frac{V_i}{R_1}$$

$$H(s) = \frac{V_o}{V_i} = \frac{-sC\left(\frac{R_2}{R_1}\right)}{s^2C^2R_2 + 2sC + \left(\frac{1}{R_1} + \frac{1}{R_3}\right)}$$

$$= \frac{-s\left(\frac{1}{CR_1}\right)}{s^2 + \frac{2s}{CR_2} + \frac{1}{R_2C^2}\left(\frac{1}{R_1} + \frac{1}{R_3}\right)} = \frac{-\left(\frac{CR_2}{2CR_1}\right)\left(\frac{2s}{CR_2}\right)}{s^2 + s\left(\frac{2}{CR_2}\right) + \frac{1}{C^2}\left(\frac{1}{R_1R_2} + \frac{1}{R_1R_3}\right)}$$

$$H(s) = \frac{\left(\frac{-R_2}{2R_1}\right)s\left(\frac{\omega_0}{Q_0}\right)}{s^2 + s\frac{\omega_0}{Q_0} + \omega_0^2}$$

$A_{01} = A_{02} = 1 \Rightarrow R_2 = 2R_1$

$$\omega_0^2 = \frac{1}{C^2R_2}\left(\frac{1}{R_1} + \frac{1}{R_3}\right)$$

$$\omega_0 = \frac{1}{C}\sqrt{\frac{1}{R_1R_2} + \frac{1}{R_1R_3}}$$

$$\frac{\omega_0}{Q_0} = \frac{2}{CR_2}$$

$$Q_0 = \frac{CR_2}{2} \times \frac{1}{C}\sqrt{\frac{1}{R_1R_2} + \frac{1}{R_2R_3}}$$

$$Q_0 = \frac{1}{2}\sqrt{\frac{R_2}{R_1} + \frac{R_2}{R_3}}$$

$$\frac{R_2}{R_1} = 2$$

$$Q_0 = \frac{1}{2}\sqrt{2 + \frac{R_2}{R_3}} = 10$$

$$2 + \frac{R_2}{R_3} = 400$$

$$\frac{R_2}{R_3} = 398$$

$$R_3 = \frac{R_2}{398}$$

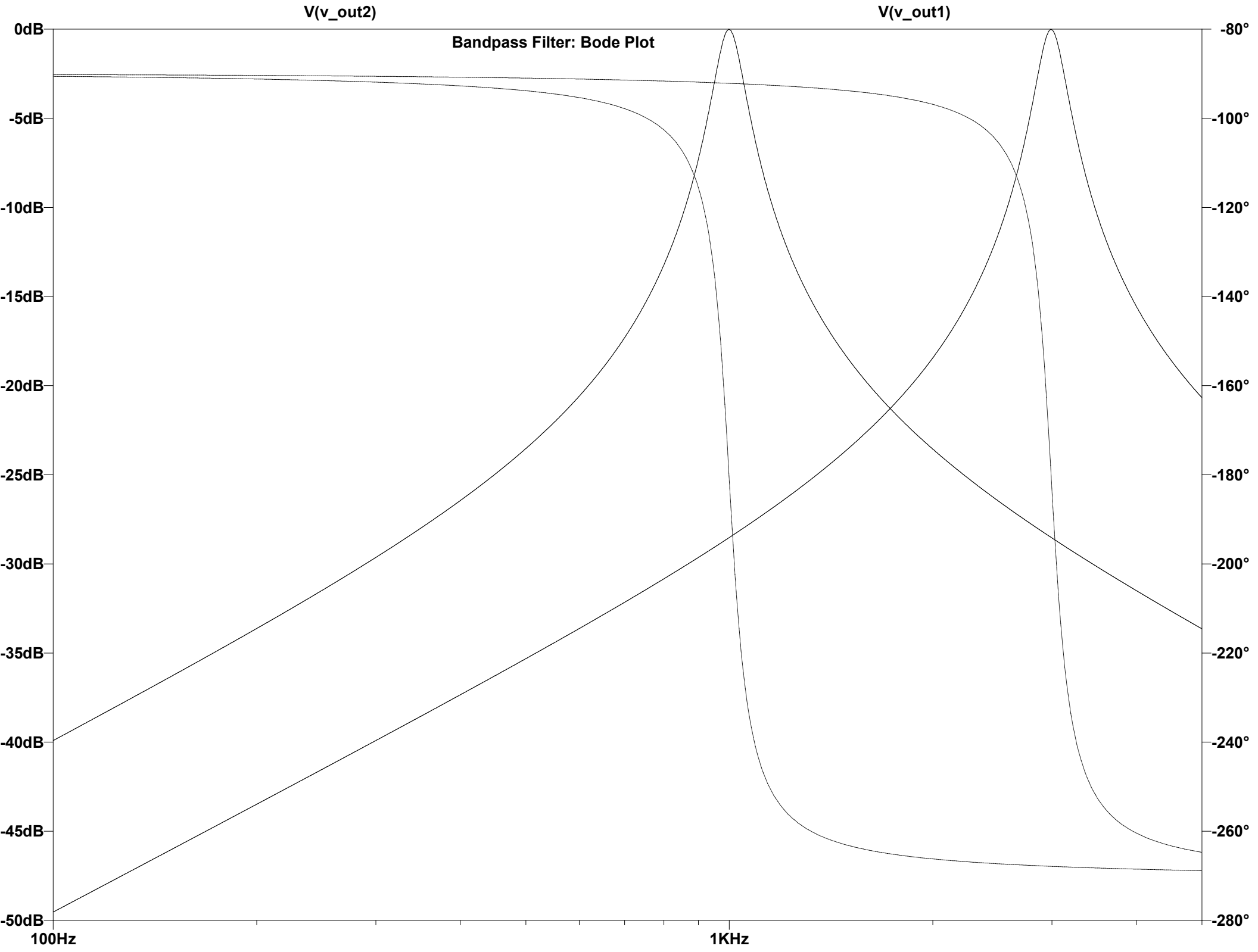
$$f_{01} = 10^3\,Hz \Rightarrow \omega_{01} = 2\pi \times 10^3 = \frac{1}{C}\sqrt{\frac{1}{R_2^2} + \frac{398}{R_2^2}}$$

$$20 \times 10^3\pi = \frac{1}{R_2C} \times 20$$

$$R_2C_1 = \frac{1}{100\pi}$$

$$f_{02} = 3 \times 10^3\,Hz \Rightarrow \frac{1}{R_2C_2} = 3 \times 2\pi \times 10^3$$

$$R_2C_2 = \frac{1}{300\pi}$$


V(v_out2)
V(v_out1)
Bandpass Filter: Bode Plot
0dB
-5dB
-10dB
-15dB
-20dB
-25dB
-30dB
-35dB
-40dB
-45dB
-50dB
-80°
-100°
-120°
-140°
-160°
-180°
-200°
-220°
-240°
-260°
-280°
100Hz
1KHz
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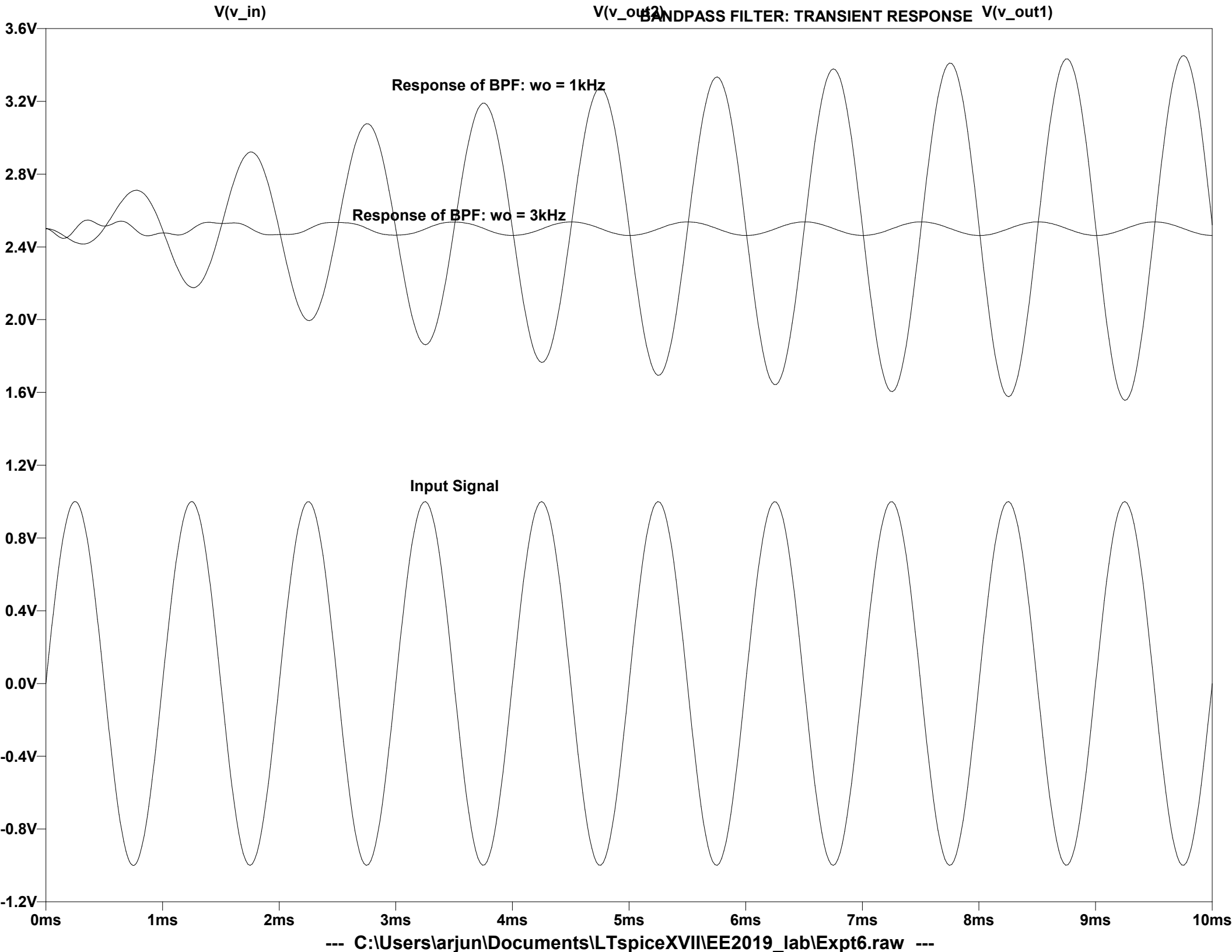
V(v_in)
V(v_out2)
BANDPASS FILTER: TRANSIENT RESPONSE
V(v_out1)
Response of BPF: wo = 1kHz
Response of BPF: wo = 3kHz
Input Signal
3.6V
3.2V
2.8V
2.4V
2.0V
1.6V
1.2V
0.8V
0.4V
0.0V
-0.4V
-0.8V
-1.2V
0ms
1ms
2ms
3ms
4ms
5ms
6ms
7ms
8ms
9ms
10ms
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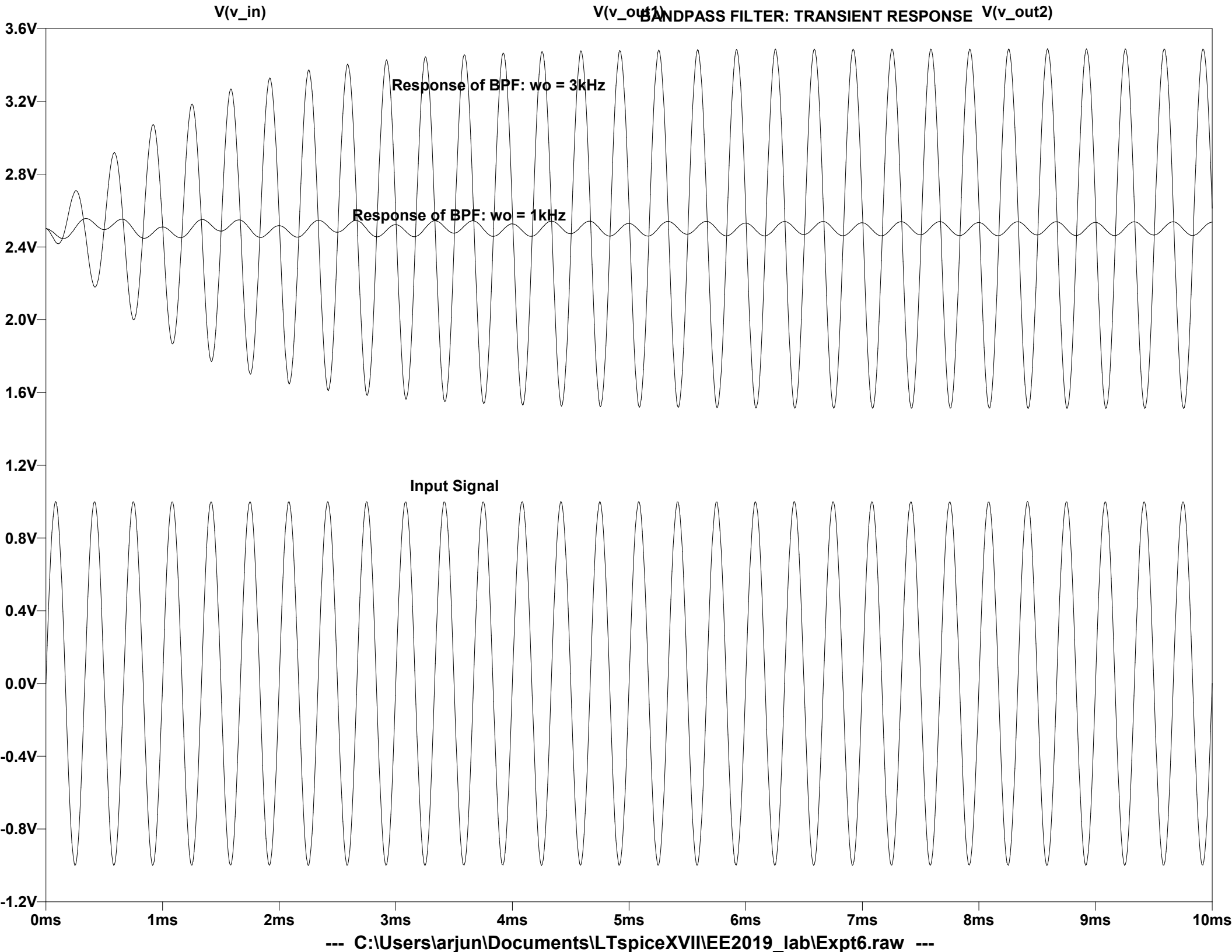
V(v_in)
V(v_out1)
BANDPASS FILTER: TRANSIENT RESPONSE
V(v_out2)
Response of BPF: wo = 3kHz
Response of BPF: wo = 1kHz
Input Signal
3.6V
3.2V
2.8V
2.4V
2.0V
1.6V
1.2V
0.8V
0.4V
0.0V
-0.4V
-0.8V
-1.2V
0ms
1ms
2ms
3ms
4ms
5ms
6ms
7ms
8ms
9ms
10ms
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