

Experiment 26

Monday, March 6, 2023 3:50 PM

Procedure

Step 1-2:

NOTE: The color and placement of channels in Figure 1 correspond to the placement and colors of channels in Figure 2

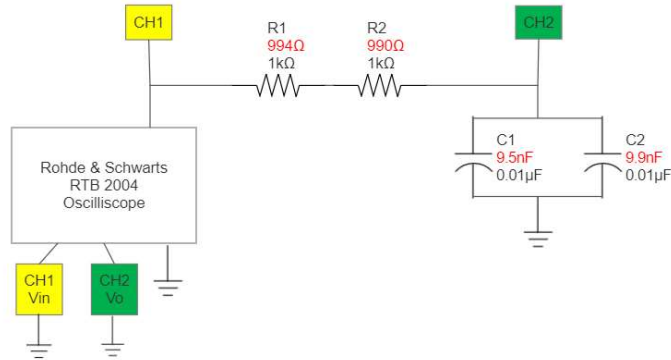


Figure 1: Circuit schematic of a Low Pass Filter

Step 3:

$$f_c = \frac{1}{2\pi * RC} = \frac{1}{2\pi * 1984 * 18.8n} = 4135 \text{ Hz}$$

Table 1: Corner frequency Calculations	Frequency [Hz]	Frequency [rad/s]
Measured	4335	27238

Step 4-6:

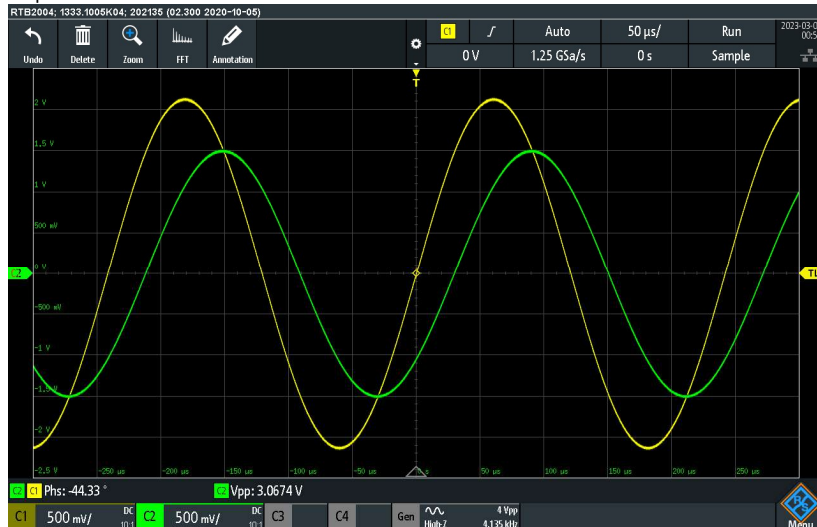


Figure 2: Oscilloscope image of corner frequency of Figure 1

Table 2: Varied Frequency and Voltage for Figure 1	Frequency [rad/s]	Frequency [Hz]	Vin [Vpp]	Vo < Θ [Vpp]	Gain [V/V]	Gain [dB]
fr/10	1257	200	1	4.1 < -3	4.1	12.256
	2721	433	1	4.1 < -6	4.1	12.256
	3770	600	1	4.1 < -9	4.1	12.256
	5027	800	1	4 < -12	4	12.041
	6283	1000	1	4 < -15	4	12.041
fr	12566	2000	1	3.8 < -26	3.8	11.596
	27238	4335	1	3.06 < -44	3.06	9.714
	37699	6000	1	2.5 < -55	2.5	7.959
	50266	8000	1	2.1 < -62	2.1	6.444
	62832	10,000	1	1.7 < -67	1.7	4.609

	125664	20,000	1	.970 < -78	0.97	-0.265
fr*10	272376	43,350	1	.480 < -84	0.48	-6.375
	376991	60,000	1	.340 < -88	0.34	-9.370
	502655	80,000	1	.254 < -88	0.254	-11.903
	628319	100,000	1	.208 < -90	0.208	-13.639

Step 7-10:

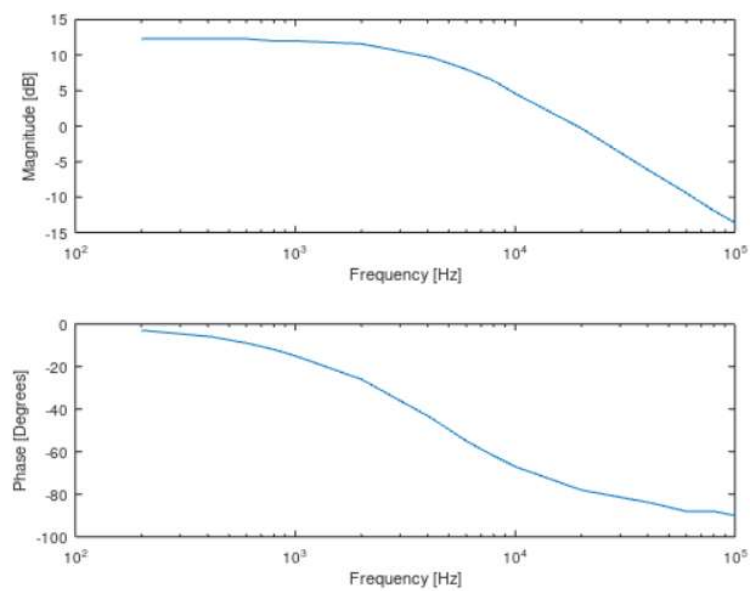


Figure 3: Bode plot of phase and magnitude for Figure 1 and Table 2 (Used Octave to create)

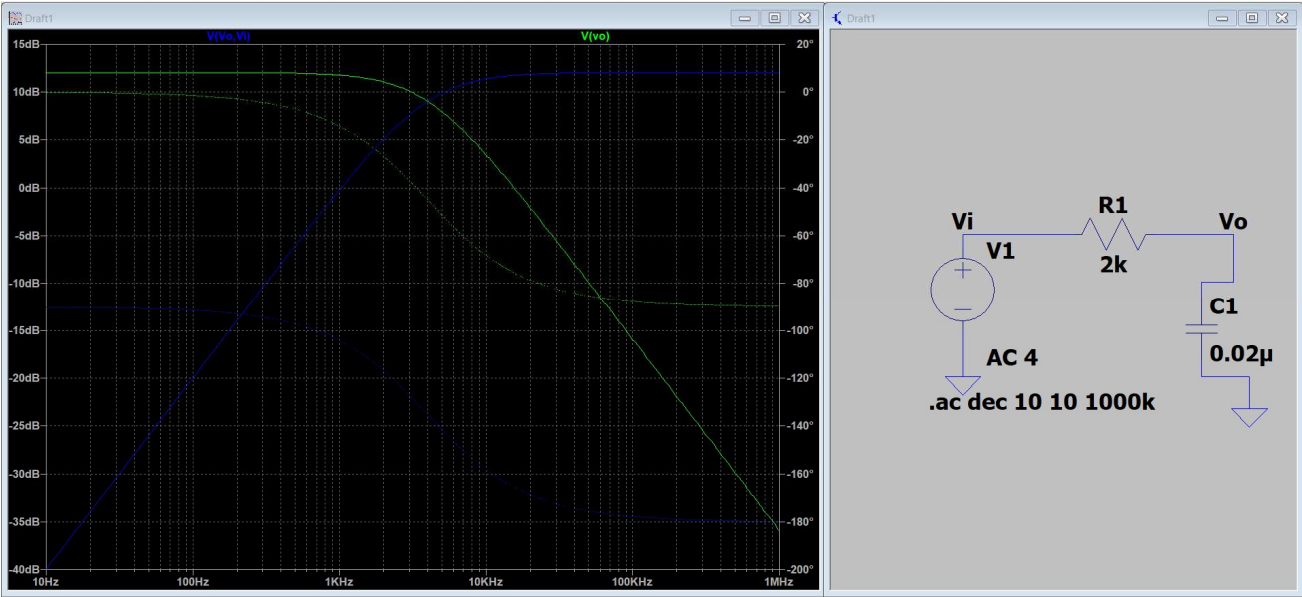


Figure 4: LTSpice simulation of with an AC sweep from 10 Hz to 1 MHz of Figure 1
If the positions of the resistor and capacitor in Figure 1 were switched, it would be a high pass filter instead of a low pass filter

Step 11-12:

NOTE: The color and placement of channels in Figure 5 correspond to the placement and colors of channels in Figure 6

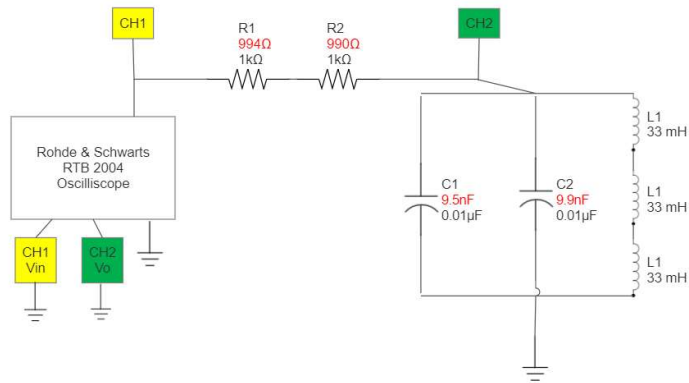


Figure 5: Circuit schematic of a Bandpass Filter

Step 13-14: calc fr and Z

$$f_c = \frac{1}{2\pi \sqrt{LC}} = \frac{1}{2\pi \sqrt{99m \cdot 18.8n}} = 3689 \text{ Hz}$$

$$Z_{eq} = R + X_c || X_l = 1984 + j \cdot 23179 \cdot 99 \cdot 10^{-3} || \frac{1}{j \cdot 23179 \cdot 18.8 \cdot 10^{-9}} = 1984 + j5.7 \cdot 10^7 \Omega$$

Table 3: Calculated and measured frequency and impedance for Figure 5 at resonant frequency	Frequency [Hz]	Frequency [rad/s]	Ze _q [Ω]
Expected	3689	23179	$1984 + j5.7 \cdot 10^7 \Omega$
Measured	4322	27156	$1984 - j7216.55 \Omega$

Step 15

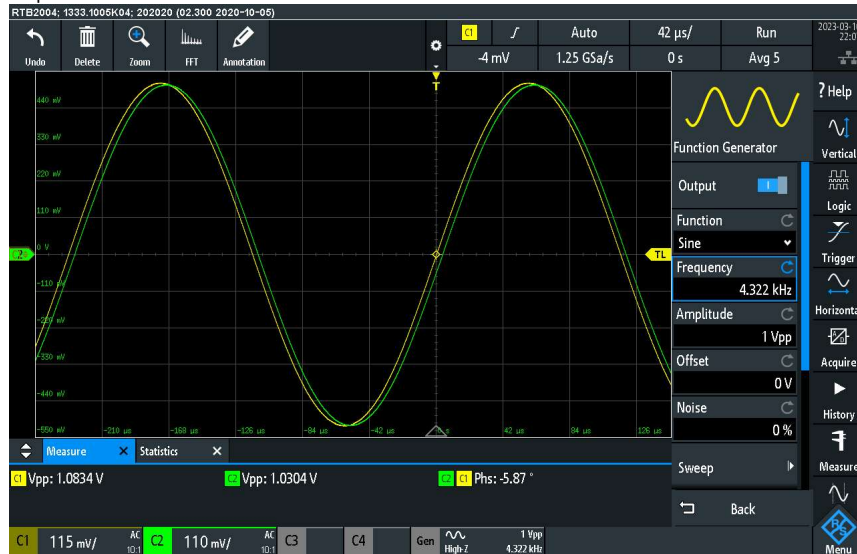


Figure 6: Oscilloscope image at resonant frequency for Figure 5

Table 4: Varied Frequency and Voltage for Figure 5	Frequency [rad/s]	Frequency [Hz]	V _{in} [Vpp]	V _o < Θ [mVpp]	Gain [V/V]	Gain [dB]
	628	100	1	44 < 34	0.044	-27.131
	1257	200	1	63 < 52	0.063	-24.013
fr/10	2716	432.2	1	118 < 66	0.118	-18.562
	3770	600	1	159 < 68	0.159	-15.972
	5027	800	1	211 < 68	0.211	-13.514
	6283	1000	1	265 < 66	0.265	-11.535
	12566	2000	1	563 < 51	0.563	-4.990
fr	27155	4322	1	1030 < -6	1.03	0.257
	37699	6000	1	858 < -35	0.858	-1.330
	50266	8000	1	645 < -52	0.645	-3.809
	62832	10,000	1	509 < -61	0.509	-5.866
	125664	20,000	1	248 < -76	0.248	-12.111

fr*10	271559	43,220	1	116 < -84	0.116	-18.711
	376991	60,000	1	85 < -87	0.085	-21.412
	502655	80,000	1	64 < -88	0.064	-23.876
	628319	100,000	1	52 < -89	0.052	-25.680

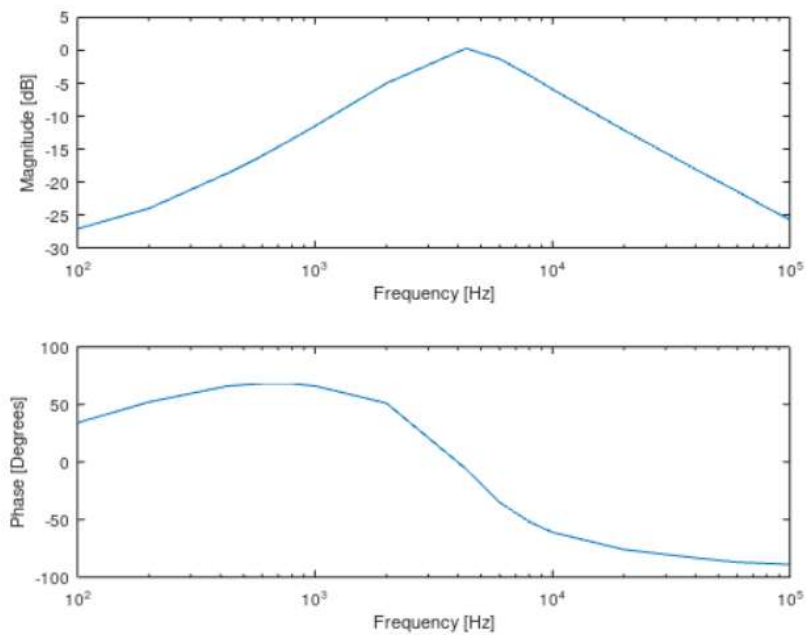


Figure 7: Bode plot of phase and magnitude for Figure 5 and Table 4 (Used Octave to create)

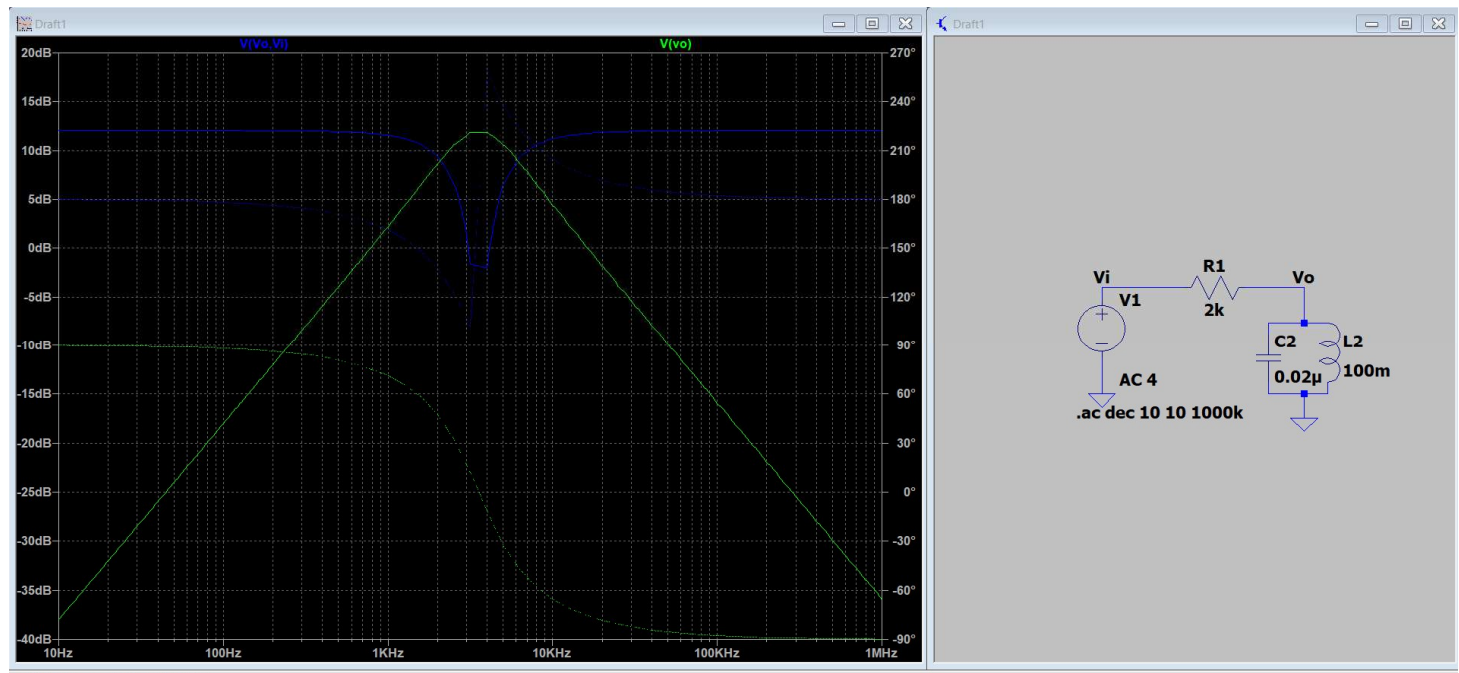


Figure 8: LTSpice simulation of with an AC sweep from 10 Hz to 1 MHz of Figure 5

Determine filter bandwidth from Figure 7: 3000 6000

On Figure 7, find the points on the bode plot where there is a 3dB change from the resonant frequency. In this case we get the values $f_1 = 3000$ Hz and $f_2 = 6000$ Hz.

$$B = 2\pi * (f_2 - f_1) = 18,8496 \text{ rad/s}$$

Notch Filter:

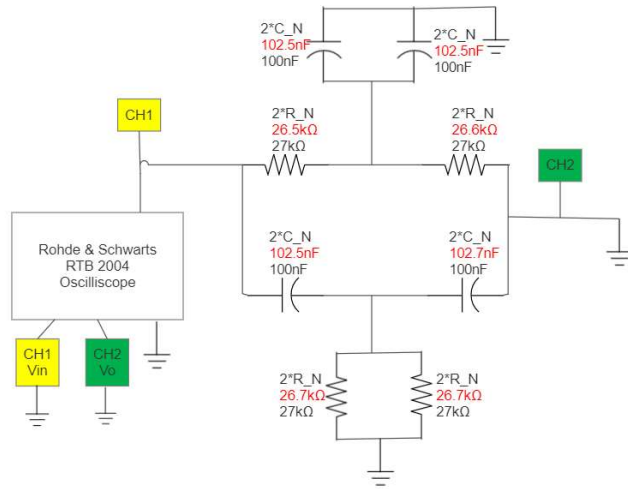


Figure 9: Circuit schematic of a Notch Filter

$$f_c = \frac{1}{4\pi * R_N * C_N} = \frac{1}{4\pi * 13.35k * 205n} = 58.15 \text{ Hz}$$

Table 5: Calculated corner frequency	Frequency [Hz]	Frequency [rad/s]
Expected	58.15	365.37

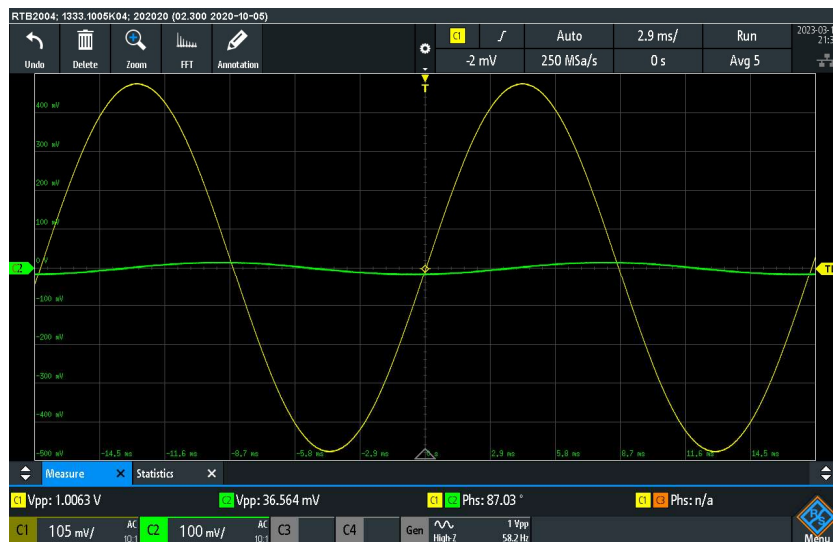


Figure 10: Oscilloscope image of Figure 9 at the corner frequency

Table 6: Varied Frequency and Voltage for Figure 9	Frequency [rad/s]	Frequency [Hz]	Vin [Vpp]	Vo < Θ [mVpp]	Gain [V/V]	Gain [dB]
fr/10	13	2	1	990 < -7	0.990	-0.087
	25	4	1	966 < -15	0.966	-0.300
	37	5.82	1	933 < -21	0.933	-0.602
	50	8	1	882 < -28	0.882	-1.091
	63	10	1	829 < -34	0.829	-1.629
fr	126	20	1	564 < -55	0.564	-4.974
	251	40	1	220 < -76	0.220	-13.152
	371	58.15	1	33 < -86	0.033	-29.630
	503	80	1	132 < 78	0.132	-17.589
	628	100	1	243 < 74	0.243	-12.288
fr*10	1257	200	1	587 < 53	0.587	-4.627
	2513	400	1	841 < 32	0.841	-1.504
	3707	581.5	1	920 < 23	0.920	-0.724
	5027	800	1	961 < 17	0.961	-0.346

	6283	1000	1	$982 < 14$	0.982	-0.158
	12566	2000	1	$1032 < 7$	1.032	0.274

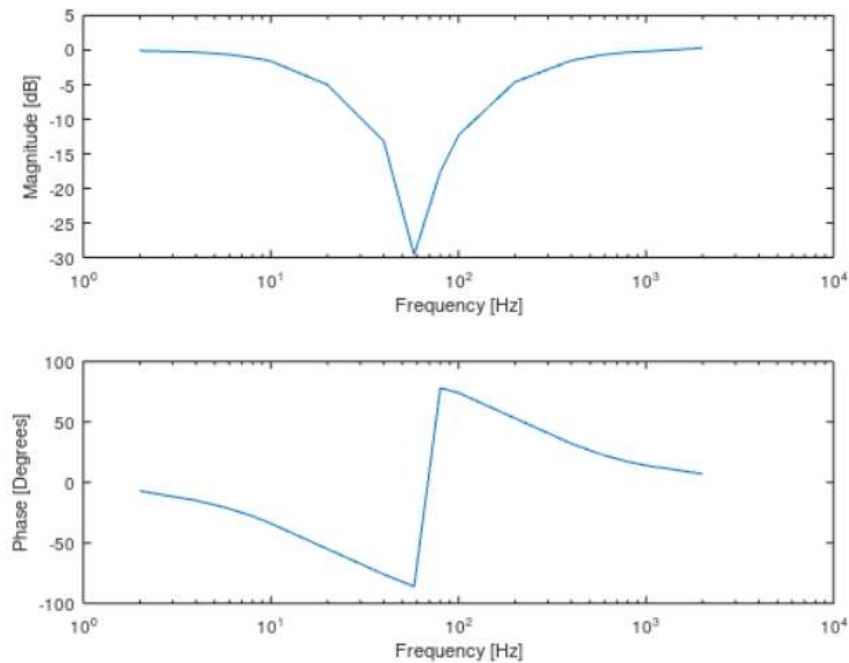


Figure 11: Bode plot of phase and magnitude for Figure 9 and Table 6 (Used Octave to create)

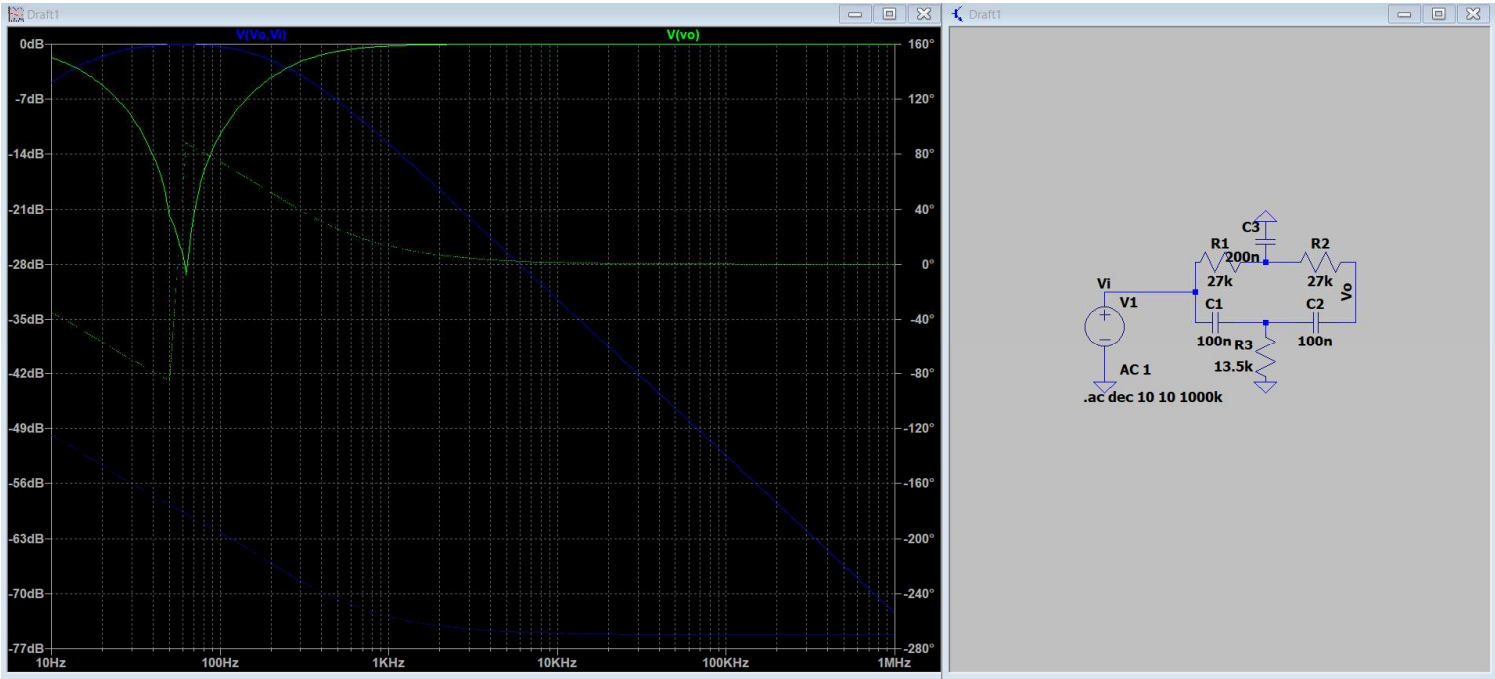


Figure 12: LTSpice simulation of with an AC sweep from 10 Hz to 1 MHz of Figure 9