Grading: Pick part a or b in Units 1, 2, 3 (Problems 3-6), You must answer both Problem 1 and Problem 2 This Homework will replace lowest homework score

Problem 1) Filter Design 1

Design a filter that meets the specifications below. You need to pick values for any resistors, capacitors or inductors in your circuit. Simulate the circuit in PSpice to verify that your design meets specifications. Use the ideal amplifier component called OPAMP in your simulations. Note, small deviations from the design specifications are allowed and in a real circuit always exist, but they need to be small. Show calculations to justify your design (guessing in PSpice is not a design solution). (note: this problem has units Hz)

a. Highpass filter with a cutoff frequency of 159MHz
b. In the specified frequency range, the gain must be >-3dB
c. The rolloff in the stopband should be 80dB
d. The circuit should contain a single unity gain (voltage follower) amplifier stage (no other amplifiers should be in your circuit).

second order -

I can't solve this one. I know its 2nd order and the voltage follower looks like

. anything else I don't know.

Problem 2) Filter Design 2

Design a filter that meets the specifications below. You need to pick values for any resistors, capacitors or inductors in your circuit. Simulate the circuit in PSpice to verify that your design meets specifications. Note, small deviations from the design specifications are allowed and in a real circuit always exist, but they need to be small. Show calculations to justify your design (guessing in PSpice is not a design solution).

ω [rad/s]	|H(s)| in dB
10	6
100	6
1000	6
1E4	3
1E5	-14
1E6	-34

6 gain of op amp

159Hz

cut off = $\frac{10^4}{2\pi}$ =

-11 db per decade

-20 db/decade

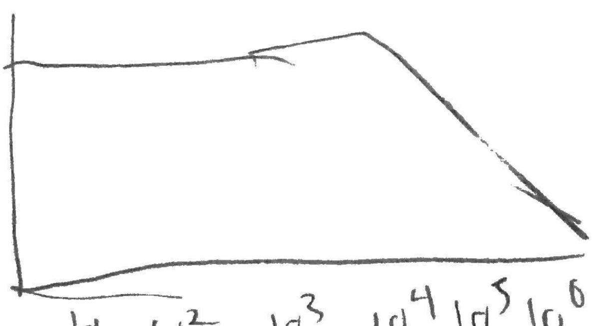
straight line approximation of -20db/decade

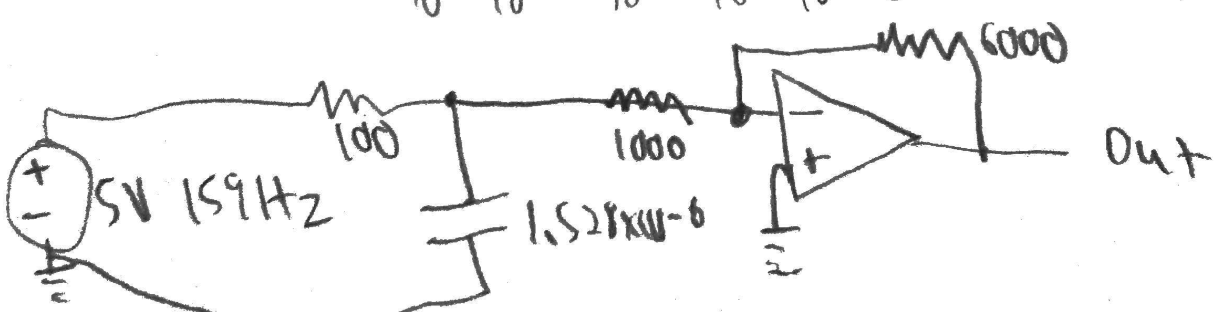
pick R = 100

$\frac{1}{RC}$ = 159

$C = 1.528 \times 10^{-6}$ F

low pass





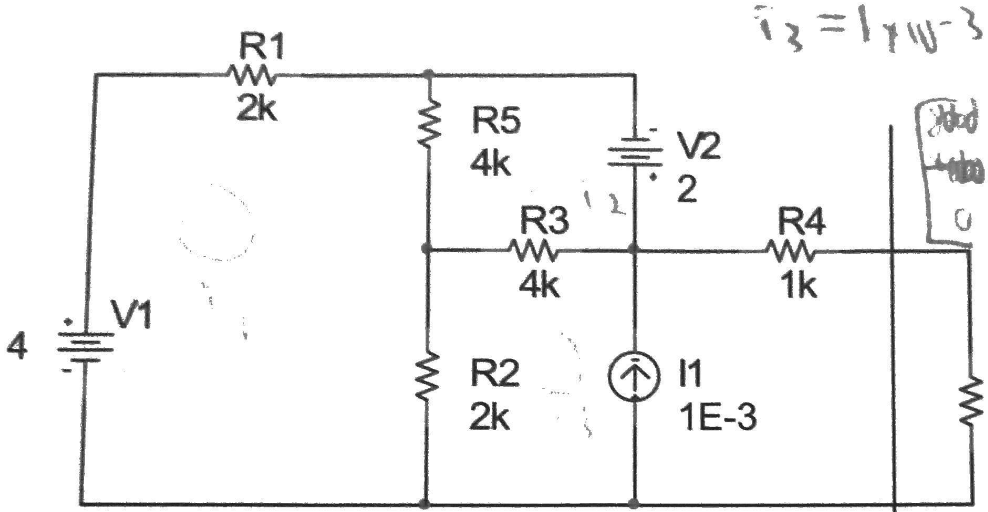
Problem 3) Thevenin/Norton

$-4 + 2000i_1 + 4000i_1 - 4000i_2 + 2000i_1 + 2000i_3 = 0$

$4000i_2\ 4000i_1 + 4000i_2 - 4000i_3 - 2 = 0$

$i_3 = 1 \times 10^{-3}$

a. Find the Thevenin equivalent circuit.



$$\begin{bmatrix} 8000 & -4000 & -2000 \\ -4000 & 8000 & -4000 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 4 \\ 2 \\ 1\times10^{-3} \end{bmatrix}$$

$i_1 = 0.0015$

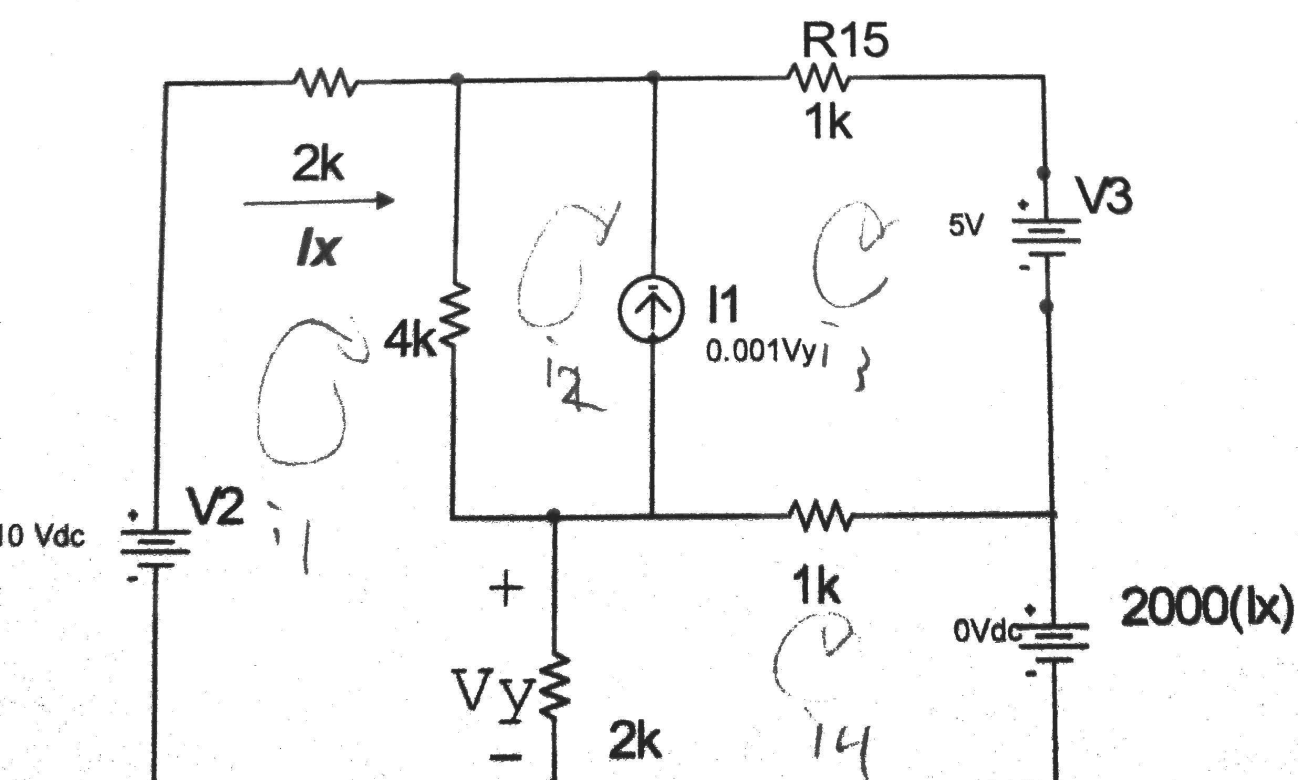
$i_2 = 0.0015$

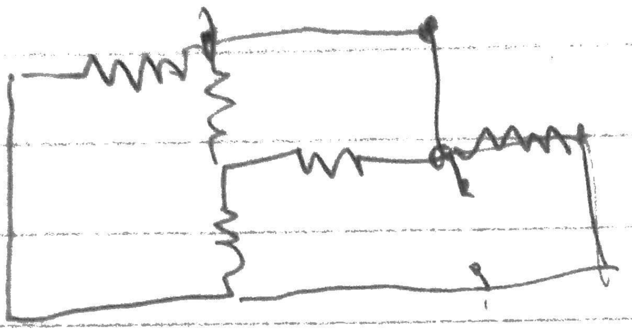
$i_3 = .001$

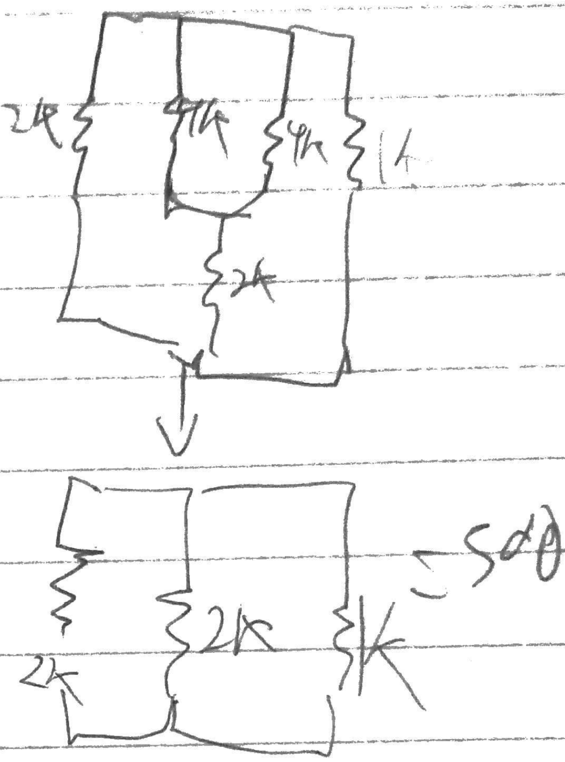
$-(i_1 - i_3)R_2 + (i_3 - i_2)R_3 + x = 0$

$x = 3 = V_{I_1} = V_{TH}$

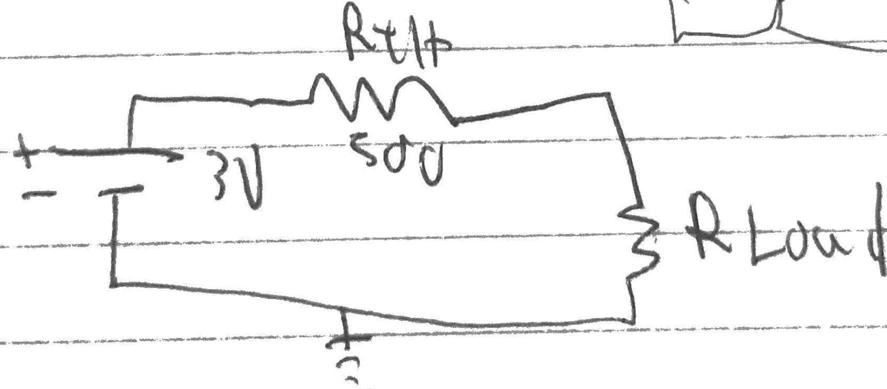
b. Find the current through the 4k resistor





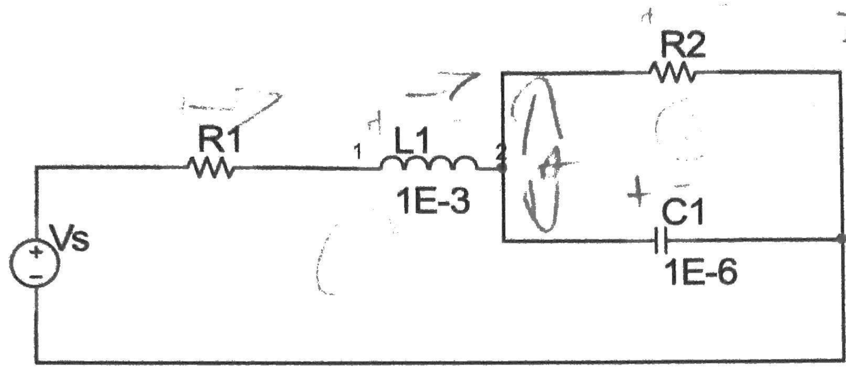


3A:



Problem 4) Differential Equations and Laplace

a. Differential equations



$I_{L_1} = I_{R_2} + I_{C_1}$

$I_{L_1} = \frac{V_C}{R_2} + C\frac{dV_C}{dt}$

$I_{L_1} = I_{R_1}$

$\frac{V_C}{R_2} + C\frac{dV_C}{dt} = I_{R_1}$

$\frac{V_C}{R_2} + C\frac{dV_C}{dt} = \frac{V_S - V_L - V_C}{R}$

1. Determine the differential relationship for the voltage across C1.

$\frac{V_C}{R_2} + C\frac{dV_C}{dt} = \frac{V_S - L\left(\frac{1}{R_2}\frac{dV_C}{dt} + C\frac{d^2V}{dt^2}\right) - V_C}{R_1}$

$\frac{R_1}{R_2}V_C + R_1C\frac{dV_C}{dt} = V_S - \frac{L}{R_2}\frac{dV_C}{dt} + LC\frac{d^2V}{dt^2} - V_C$

$-LC\frac{d^2V_C}{d^2t} + \frac{dV_C}{dt}\left(R_1C + \frac{L}{R_2}\right) + V_C\left(\frac{R_1}{R_2} + 1\right) = V_S$

$\frac{dV_C^2}{d^2t} - \frac{R_1CR_2 + L}{LCR_2}\frac{dV_C}{dt} - \frac{R_1 + R_2}{LCR_2} = -\frac{V_S}{LC}$

1:

2. Determine values for R1 and R2 so that the circuit is underdamped.

2: We choose an extremely high resistance for R_2 so it is effectively open circuit. Prof Sawyer said I could do this. like:

$R_2 = 100 \times 10^6$ ohms

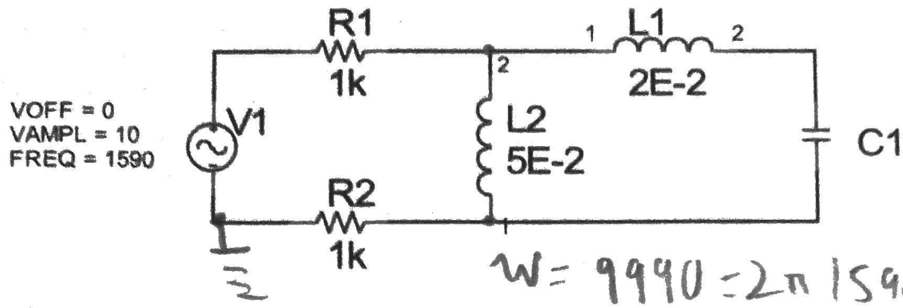
Now it is series RLC circuit

$\frac{1}{2}\frac{R_1}{L} < \frac{1}{\sqrt{LC}}$ $\quad R_1 < 63.2455$

$\boxed{R_2 = 150 \times 10^6 \text{ ohms}, \; R_1 = 50 \text{ ohms}}$

Problem 5) AC Steady State Circuit Analysis

a. Phasors



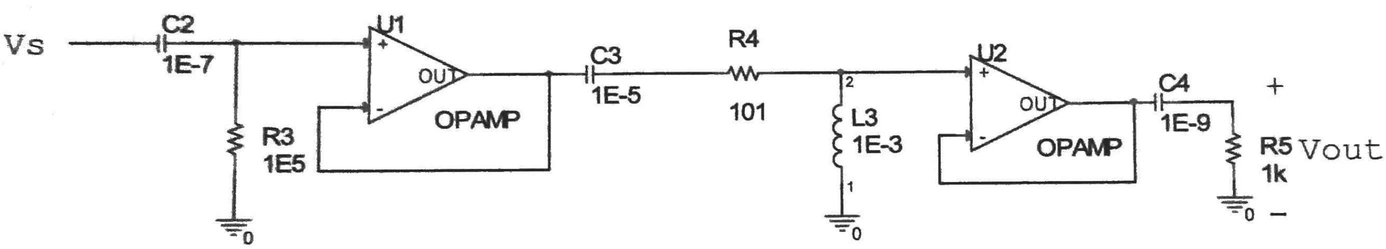
$W = 9990 = 2\pi\, 1590$

1. Determine a value for C1 so that the current through the source is 5mA and has zero phase.

$$Z_{eq} = 1000 + \left(\frac{1}{4995j} + \frac{1}{199.8j + \frac{1}{j9990C}}\right)^{-1} + 1000 = \frac{10}{5\times10^{-3} + 0j}$$

$$\boxed{C_1 = 5.005\times10^{-7}\ F}$$

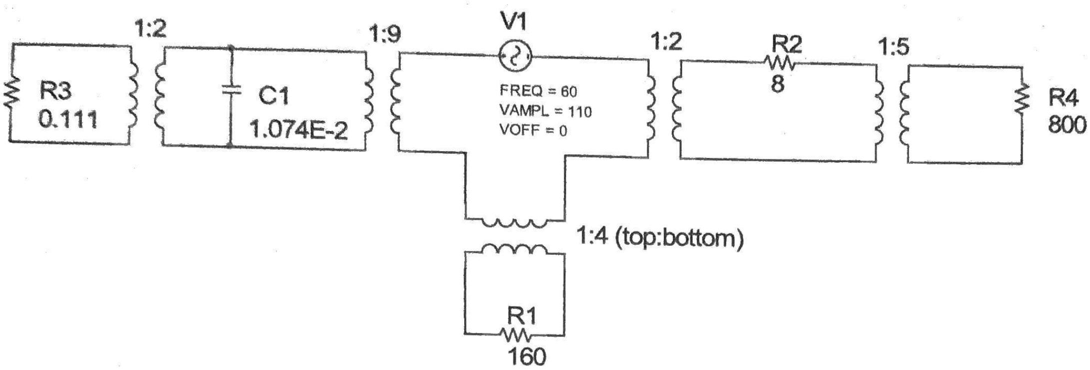
b. Frequency response



1. Sketch the Bode plots for the magnitude and phase, H(s)=Vout/Vin

Problem 6) Transformers and Power Circuits

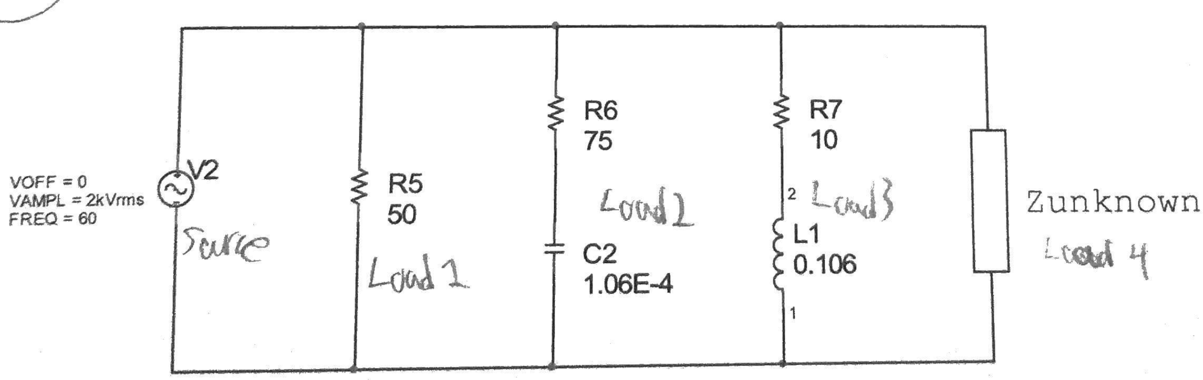
a. Transformers



1. Determine the phasor form of the current through the source.

2. Determine the total power in the left branch, (R3 and C1)

b. Power



1. Determine Zunknown such that the power produced is purely real.
2. Determine the power produced in each load and the source

$\therefore$ Load 1: $\frac{1}{2}\frac{(2k\sqrt{2})^2}{50} = 80000\ W = S$

Load 2: $\frac{1}{2}\frac{(2k\sqrt{2})^2}{75+25.02j} = 47991 - 16012j = S$

Load 3: $\frac{1}{2}\frac{(2k\sqrt{2})^2}{10+40j} = 23571.3+9428.6j = S$

Load 4: $-78159.6j = S$

Source: $\frac{(2k\sqrt{2})^2}{2 \cdot 26.4} = -151515.15 = S$

Current $Z_{eq} = \left(\frac{1}{50} + \frac{1}{75 + \frac{1}{j377 \cdot 1.06 \times 10^{-4}}} + \frac{1}{10 + j377 \cdot .186}\right)$

$\omega = 377$

$= 0.03789 - 0.01954j \qquad \frac{1}{Z_{unknown}} = 0.01954j$

$Z_{unknown} = \frac{1}{0.01954j} = -51.177j$ some capacitor $\frac{1}{j\omega C} = -51.177j$

ut

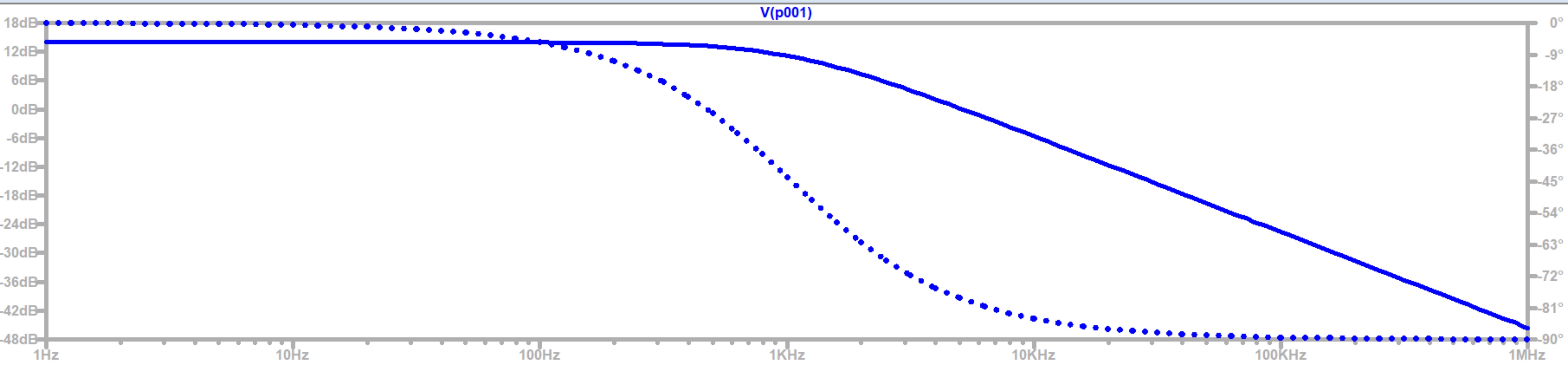
$\frac{1}{\omega C} = 51.177$

$C = 5.183 \times 10^{-5}$

verification: $\left(\frac{1}{50} + \frac{1}{75 + \frac{1}{j377 \cdot 1.06 \times 10^{-4}}} + \frac{1}{10 + j377 \cdot .186} + \frac{1}{\frac{1}{j377 \cdot 5.183 \times 10^{-5}}}\right)^{-1}$

$\boxed{1: Z_{unknown} = 5.183 \times 10^{-5}\,F}$ $= 26.4 + 0.00j$

The circuit wouldn't accept the op amp at the output of the filter in LT spice for an AC sweep so I disconnected it and as a result the gain was off. The cut off frequency is correct though.



V(p001)
18dB
12dB
6dB
0dB
-6dB
-12dB
-18dB
-24dB
-30dB
-36dB
-42dB
-48dB
0°
-9°
-18°
-27°
-36°
-45°
-54°
-63°
-72°
-81°
-90°
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz