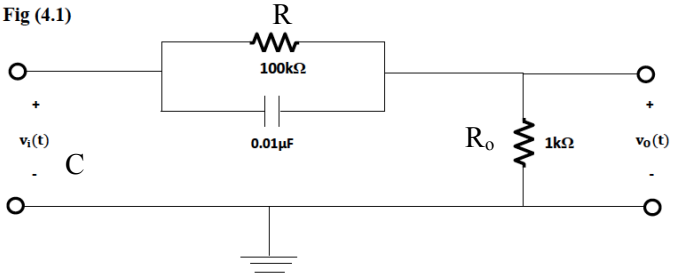
October 27, 2021 Prepared for ELE 302 TAs

EXPERIMENT #3

Frequency Response for Circuit 1

Fig (4.1)



Output voltage is obtained using voltage division between the 1 kΩ resistor (R_o) and $Z_{R//C}$.

$$Z_{R||C} = \frac{R}{1 + j\omega RC}$$

Transfer function

$$H(j\omega) = \frac{V_o(j\omega)}{V_i(j\omega)} = \frac{R_o}{R_o + Z_{R||C}} = \frac{R_o(1 + j\omega RC)}{R_o(1 + j\omega RC) + R} = \frac{R_o}{R + R_o} \frac{(1 + j\omega RC)}{(1 + \frac{j\omega R_o RC}{R + R_o})}$$

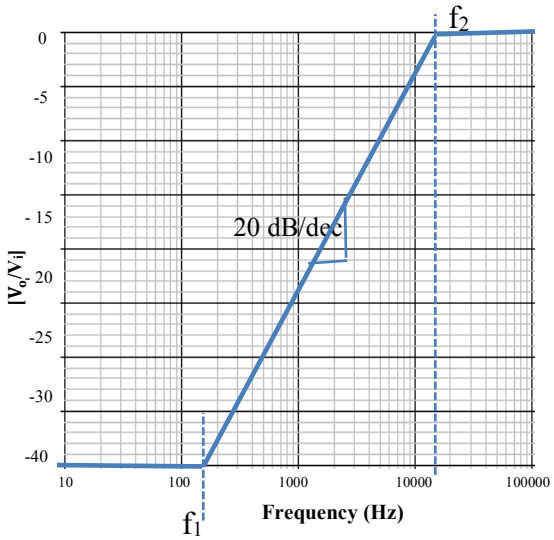
$$|H|_{dB} = \underbrace{20 \log\left(\frac{R_o}{R + R_o}\right)}_{\text{-40 dB}} + 20 \log(1 + j\omega RC) - 20\log\,(1 + \frac{j\omega R_o RC}{R + R_o})$$

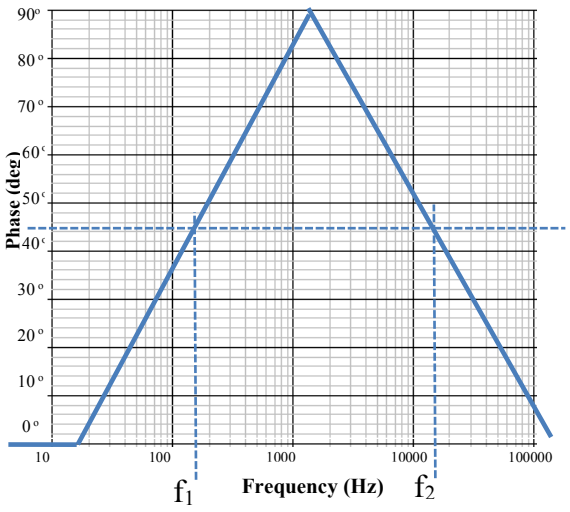
Corner Frequencies at

$\omega_1 = \frac{1}{RC} = 1000$ rad/s $f_1 = 160$ Hz (zero)

and

$\omega_2 = \frac{R+R_o}{R_o RC} = 101{,}000$ rad/s $f_2 = 16\text{x}10^3$ Hz (pole)





In the instructions, they were asked to find fz and fp. These are the zero and pole (corner frequencies) of the transfer function. There are 2 ways of getting them: 1. From the phase shift plot at +/- 45 degree 2. From the magnitude plot: find the corner of the asymptotic plots.

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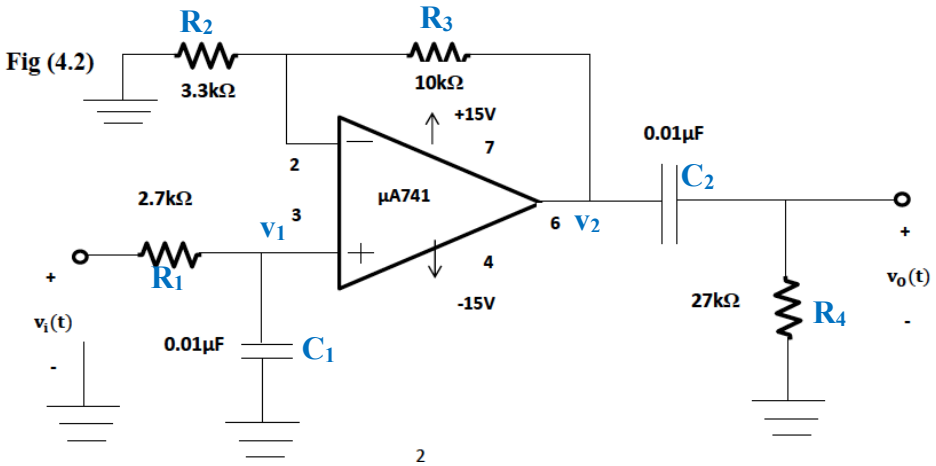
Frequency Response for Circuit 2



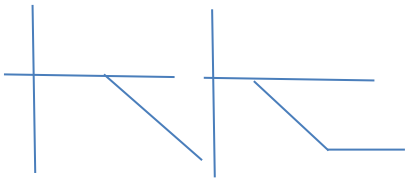
To get the transfer function H(jw), we need to find v_1/ v_i and $v_{2/} v_1$, and $v_{o/} v_2$

$$H(j\omega) = \frac{V_o}{V_2}\frac{V_2}{V_1}\frac{V_1}{V_i} = H_3H_2H_1$$

1) Using voltage division to get v_1/ v_i

$$H_1 = \frac{V_1}{V_i} = \frac{1}{1 + j\omega R_1C_1}$$

corner frequency at $\omega_1 = \frac{1}{R_1C_1} = 37$ k rad/s $f_1 = 5{,}893$ Hz



2) Non-inverting amplifier (or nodal analysis at Pin 2) to get $v_{2/} v_1$

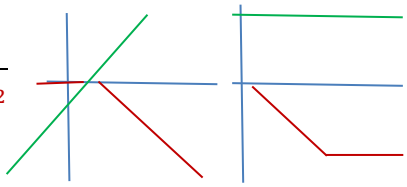
$$H_2 = \frac{V_2}{V_1} = 1 + \frac{R_3}{R_2}$$

3) Using voltage division to get $v_{o/} v_2$

$$H_3 = \frac{V_o}{V_2} = \frac{j\omega R_4C_2}{1 + j\omega R_4C_2}$$

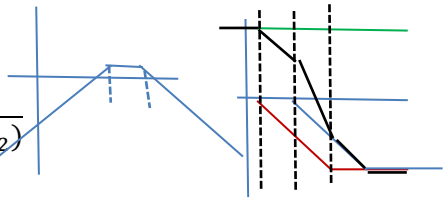
corner frequency at $\omega_2 = \frac{1}{R_4C_2} = 3.7$ k rad/s $f_2 = 589$ Hz

and a zero at the origin



Combining all three stages together, one zero and two poles:

$$H(j\omega) = \left(1 + \frac{R_3}{R_2}\right)R_4C_2\,\frac{j\omega}{(1 + j\omega R_1C_1)(1 + j\omega R_4C_2)}$$



With a constant gain of $(1+R_3/R_2)R_4C_2 = 0.001$

$20 \log(0.001) = -60$ dB at $\omega = 1$ rad/s (f=0.16 Hz)

Time-mode phase angle: deltaT/T x360 = deltaT x f x 360 (output Leading: output at left of input is +ve)

XY-mode phase angle: Please follow the instructions from ELE 202 Experiment instruction as below: