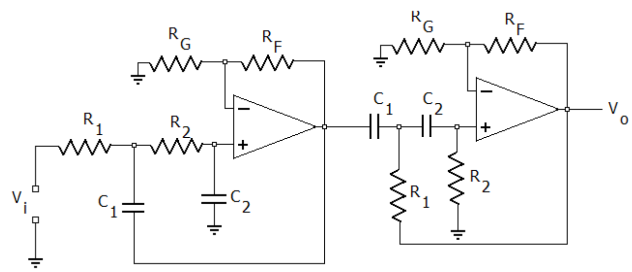
Electronics

Band pass filter

Problem 1.- For a PLC (Power Line Carrier) application, design a band pass filter from 200kHz to 300kHz and drops of 40dB per decade on both sides of the band. Use only two opamps.

Solution: The solution uses two active filters with two poles, as shown below:



The first stage is the low pass filter and we select the components to have a cutoff frequency of 300kHz

$$R_1C_1 = R_2C_2 = \frac{1}{2\pi \times 300kHz}$$

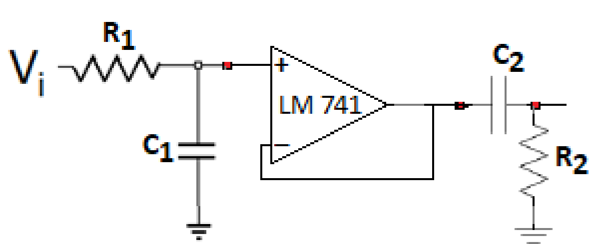
For example with R = 3.3kΩ and C = 160pF
For the second stage R = 3.6kΩ and C = 220pF will give 200kHz of cutoff frequency.

R_G and R_F can give an additional gain in the middle of the band, but that is not required in this application.

Problem 2.- A selective voltmeter should read the voltage in a range of frequencies from 200kHz to 240kHz.

a) Design a band pass filter with those two cutoff frequencies and drop of 20dB per decade on each side of the band.
b) Calculate the gain in the middle of the band at 220kHz.

Solution: A simple low pass RC filter connected through a voltage follower with another Rc filter can do what we need. The low pass filter is set to 240kHz and the high pass to 200kHz.



For example using these values

$R_1 = 660\Omega$

$R_2 = 790\Omega$

$C_1 = 1nF$

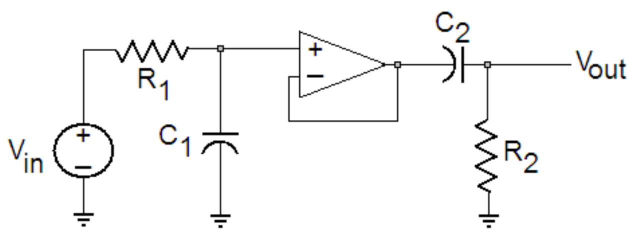
$C_2 = 1nF$

The gain at 220kHz is

$$\frac{v_o}{v_i} = \frac{1}{\sqrt{1+\left(\frac{220kHz}{240kHz}\right)^2}} \frac{1}{\sqrt{1+\left(\frac{200kHz}{220kHz}\right)^2}} = 0.545$$

This is a drop of 5 dB.

Problem 3.- In the following band-pass filter you want the low cut-off frequency to be 2kHz and the upper cut-off to be 15kHz.



(a) Find reasonable values of R_1, C_1, R_2 and C_2 to get the desired response.

(b) What is the gain for a frequency of 20 kHz?

Solution:

The combination R_1 and C_1 behaves as a low pass filter, so we want:

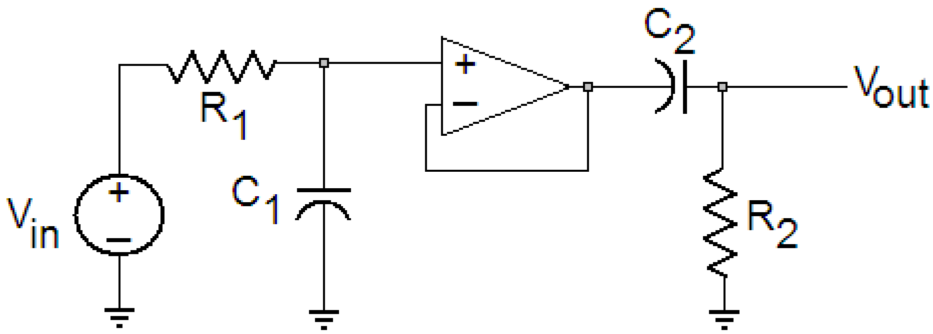
$$15kHz = \frac{1}{2\pi R_1 C_1} \rightarrow R_1 = \frac{1}{2\pi C_1 (15kHz)}$$, for example 22nF and 480Ω

The combination R_2 and C_2 behaves as a high pass filter, and here we want:

$$2kHz = \frac{1}{2\pi R_1 C_1} \rightarrow R_1 = \frac{1}{2\pi C_1 (2kHz)}$$, for example 22nF and 3.6kΩ

The gain for a frequency of 20 kHz is 0.6 or -4.4dB

Problem 4.- In the following band-pass filter the values of the resistors and capacitors are as follows: $C_1 = 22\text{nF}$ $R_1 = 330\Omega$ $C_2 = 470\text{nF}$ $R_2 = 1.0\text{k}\Omega$



(a) Find the high and low cut-off frequencies.
(b) Graph the gain as a function of frequency.
(c) What is the gain for a frequency of 300Hz?

Solution: The circuit on the left of the opamp will behave as a low pass filter with a cutoff frequency of:

$$f_2 = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi(330\Omega)(22\text{nF})} = 21{,}900 \text{ Hz}$$

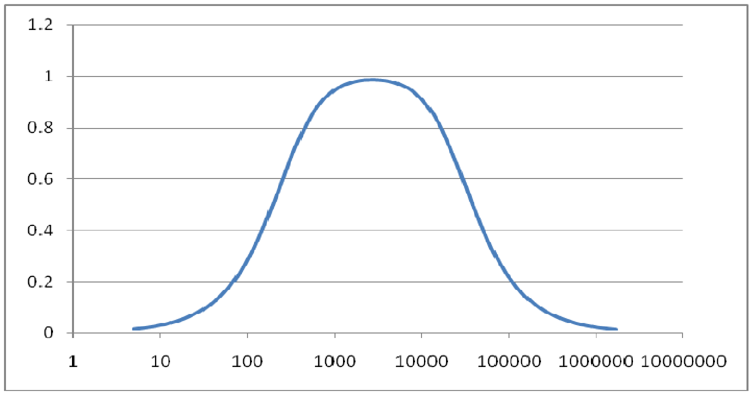
On the other hand, the circuit on the right of the opamp will behave as a high pass filter with a cutoff frequency of:

$$f_1 = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi(1\text{k}\Omega)(470\text{nF})} = 340 \text{ Hz}$$

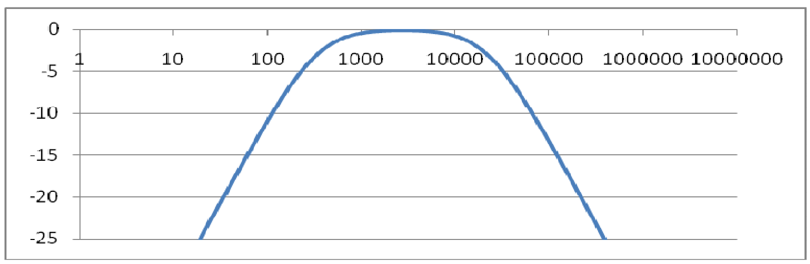
The overall gain will be:

$$A = \left[\frac{1}{\sqrt{1+(f/21{,}900)^2}}\right]\left[\frac{1}{\sqrt{1+(340/f)^2}}\right]$$

Whose graph looks as follows:



In decibels the graph will be:



At 300 Hz the gain is 0.66 or -3.6dB