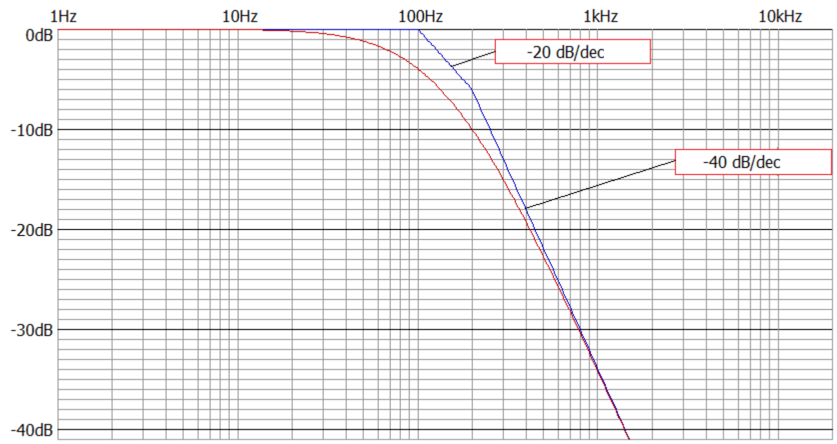
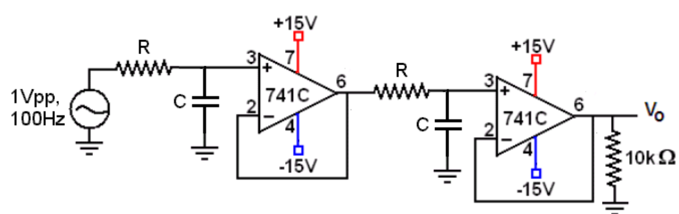
Electronics

Low Pass Filter

Problem 1.- For an geophysics exploration application, the signal from a geophone has to be filtered according to the Bode diagram shown below. Design a filter with that response.



Solution: According to the Bode diagram, we need a low-pass filter with two poles, one at 100Hz and the other at 200Hz. This is a typical application before the data is digitized. Two single poles filters in cascade will solve the problem.



For the first filter, we can choose 1.3kΩ and 1.2μF and for the second filter 2.4kΩ and 0.33μF.

Problem 2.- You have a signal that will be sampled at 6ms and you want to filter it to avoid the effect of folding over the signal above the Nyquist frequency.
Design a filter with a cut-off frequency at 80% of the Nyquist and 20dB decay per decade.

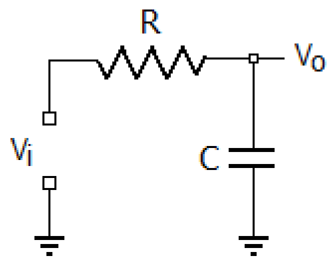
Solution: The Nyquist frequency is

$$f_N = \frac{1}{2T} = \frac{1}{2(6ms)} = 83.3Hz$$

We want the filter to have the cut-off frequency at:

$$f_C = 80\% \times 83.3Hz = 66.7Hz$$

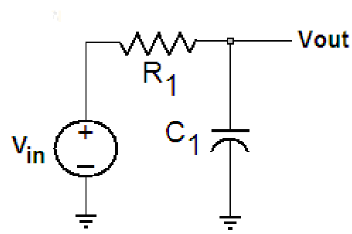
A single pole filter like the one below can solve the problem:



The values of RC have to be such that $f = \frac{1}{2\pi RC} \rightarrow RC = \frac{1}{2\pi f} = 2.39ms$

A possible combination is C= 2.4μF and R 1kohm.

Problem 3.- In the following filter $C_1 = 22\text{nF}$ and $R_1 = 330\Omega$. Calculate the cutoff frequency and estimate the gain in decibels for a frequency f = 2.2 MHz. What kind of filter is this?



Solution: The filter is low-pass with a cut-off frequency of

$$f_c = \frac{1}{2\pi R_1 C_1} = \frac{1}{2(3.1416)(22\times10^{-9}\text{F})(330\Omega)} = 21.9\text{ kHz}$$

To get the gain at 2.2 MHz we plug this value in the equation:

$$G = \frac{1}{\sqrt{1+\left(\frac{f}{f_{o1}}\right)^2}} = \frac{1}{\sqrt{1+\left(\frac{2.2\text{MHz}}{21.9\text{kHz}}\right)^2}} = 0.009954,$$

Which in decibels is: $G_{dB} = 20\log(0.009954) =$ **-40 dB**