Design of a filter

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Abstract

A filter is going to be designed by making use of the transferring function given.

Feasibility analysis

I want to get a high pass filter with the transferring function. By using the transferring function we are going to generate a Bode diagram that looks like this:

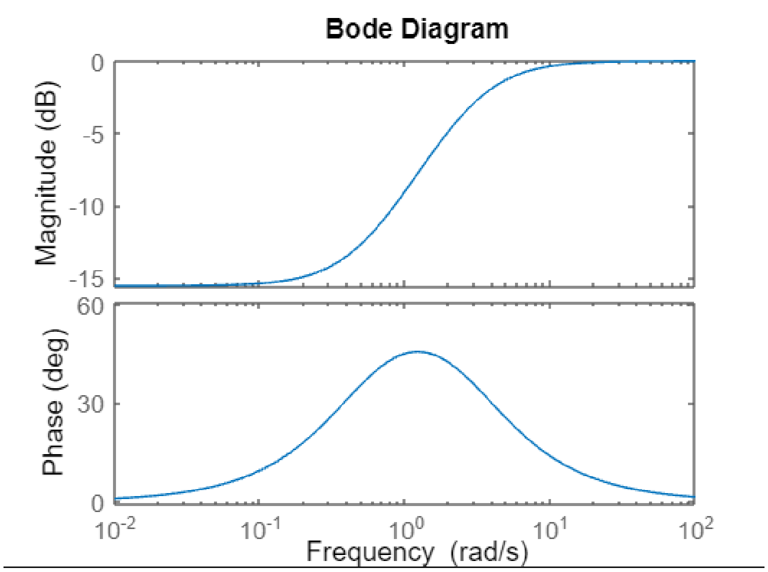

Figure 1: Bode diagram.

What does a filter is?

In electronics a filter is a set of electronic components that create a circuit and this circuit lets pass signals through it, to a certain frequency or frequency ranges meanwhile it prevents the pass of other signals, modifying its amplitude and phase. Filters can be digital or analog.

Analog filters are those in which the signal can take any value within an interval. An analog filter is a filter used for analog processes or continuous-time signals. Analog filters are divided into passive filters and active filters, depending on the type of elements used for their realization.

Digital filters just take discrete values.

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Filters are also classified depending on the functions they perform. Filters are two-port systems, one input and one output, that work in the frequency domain. Its operation is based on blocking signals in terms of their spectral content, letting through signals whose frequency is within a certain range known as the pass band and rejecting those signals outside this range, known as the stop band. A filter works on input signals producing an output signal whose spectral content depends on the type of filter.

There are different types of filters depending on the specific application they perform. In practical terms, there are four basic types of filters (Low Pass, High Pass, Band Pass, and Band Stop);

In the low-pass filter, only low-frequency signals pass, but it blocks or rejects high-frequency signals. This happens the other way around in the high-pass filter, since it allows high-frequency signals to pass, blocking low-frequency signals below the frequency cutting. Then we find the band pass filters which allow the passage of frequencies that are between a range w1 and w2, called the lower cutoff frequency and the higher cutoff frequency, where it blocks frequencies outside that range. Finally, there are the band-eliminating filters in which, unlike the band-pass filter, they attenuate the frequencies that are within the w1 and w2, letting the remaining frequencies pass.

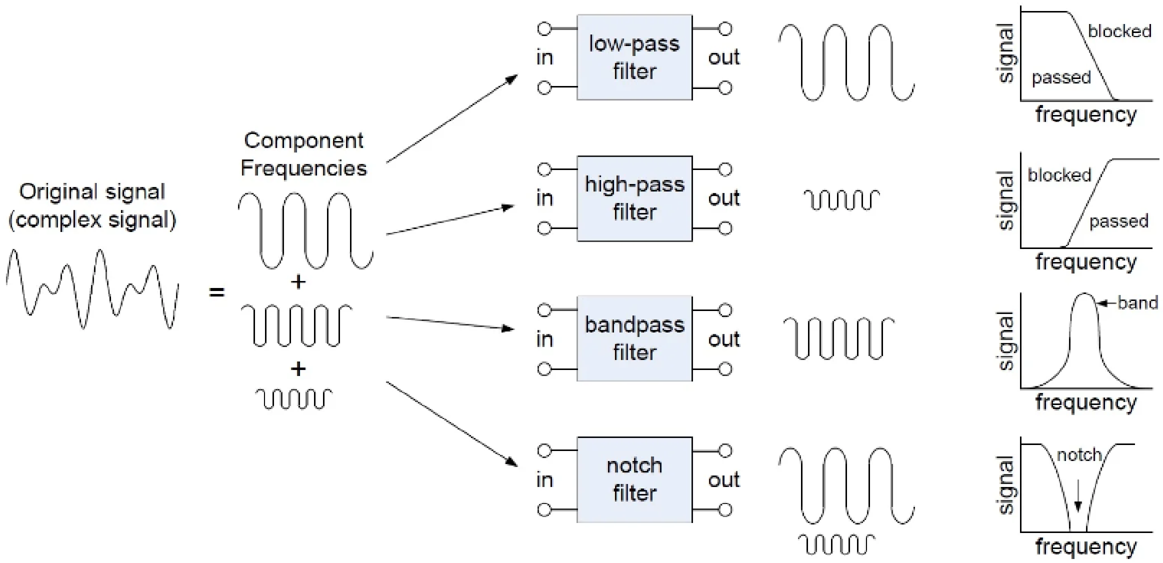

Figure 2: Filters.

Filters are usually made with opamps, resistors, capacitors and inductors.

This is the structure of the transferring function:

$$T(s) = \frac{s+z}{s+p} \tag{1}$$

Objectives, Goals and Hypothesis

I must design a filter with which doing the respective procedures so I can obtain the following transferring function:

$$T(s) = 6\frac{s+0.5}{s+3} \tag{2}$$

My purpose is to get the necessary knowledge to design any kind of filter so I can use it in work and personal activities as an engineer.

Theoretically my high pass filter has to let bands pass and must look as diagram in figure 1.

Technical specifications

I designed my filter with two opamps, two resistors with value of 166.6kOhms, two resistors with value of 10kOhms, a capacitor of 12uf and other one of 2uf.

The filter designed is the following one:

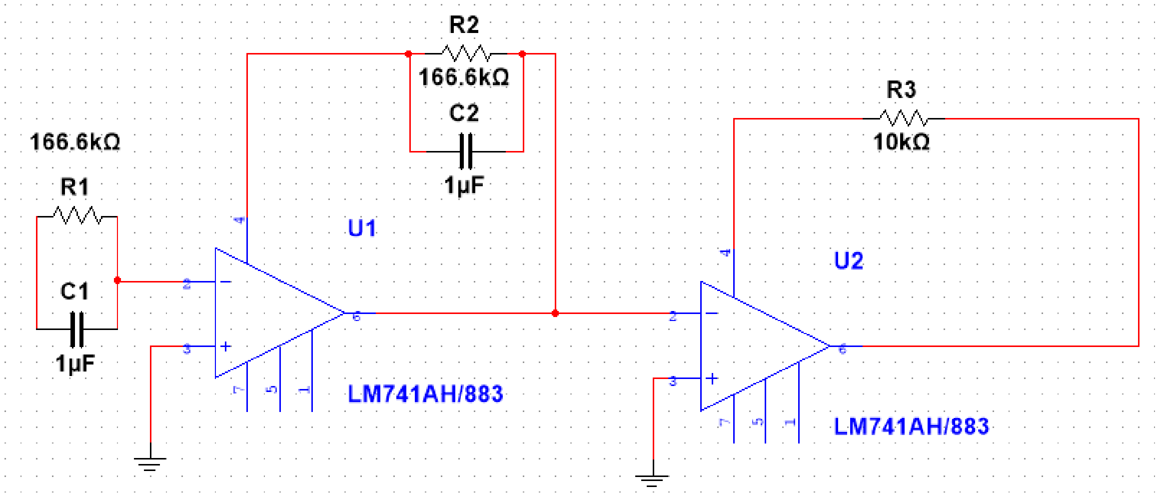

Figure 3: Simulated filter.

Normative and regulations

NOM-001-SCFI-2018. Equipos electr'onicos que se fabriquen, importen, comercialicen, distribuyan o arrienden en M'exico, con el objetivo central de prevenir riesgos a los consumidores y a su patrimonio. (Avila,S.f)

Methodology for the development of the project

All methods revolved around the transfer function.

$$T(s) = 6\frac{s+0.5}{s+3} \tag{3}$$

With this equation I was able to know the values of my resistors as well as my capacitors. Once I know all the respective values I could simulate my filter correctly and then my Bode diagram for the phase and magnitude.

Results achieved

The results were obtained with the following procedures:

$$\frac{-(s+\frac{1}{(R_1)(C_1)})C1}{(s+\frac{1}{(R_2)(C_2)})} = T(s) \tag{4}$$

With the values of my capacitors I was able to obtain the values of z and p.

$$\frac{1}{(R_1)(12uf)} = 0.5 \tag{5}$$

As you can see in equation 5, with the capacitor of 12uf I obtained the value of z.

$$\frac{1}{(R_2)(2uf)} = 3 \tag{6}$$

As you can see in equation 6, with the capacitor of 2uf I obtained the value of p.

Cut-off frequency

$$fc_1 = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi(166.6k)(12uf)} = .796Hz(Zero) \tag{7}$$

$$fc_2 = \frac{1}{2\pi R_2 C_2} = \frac{1}{2\pi(166.6k)(2uf)} = .4776Hz(Pole) \tag{8}$$

The equation of my graph is the following one:

$$0.796 = 20\log 10(x), 0.31dB \tag{9}$$

By means of the transfer function I got the following part of my filter:

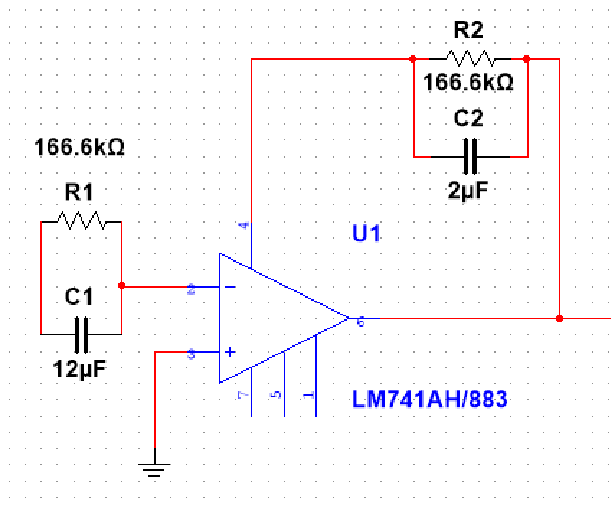

Figure 4: Part I

To this inverter I added the following part to complete my filter:

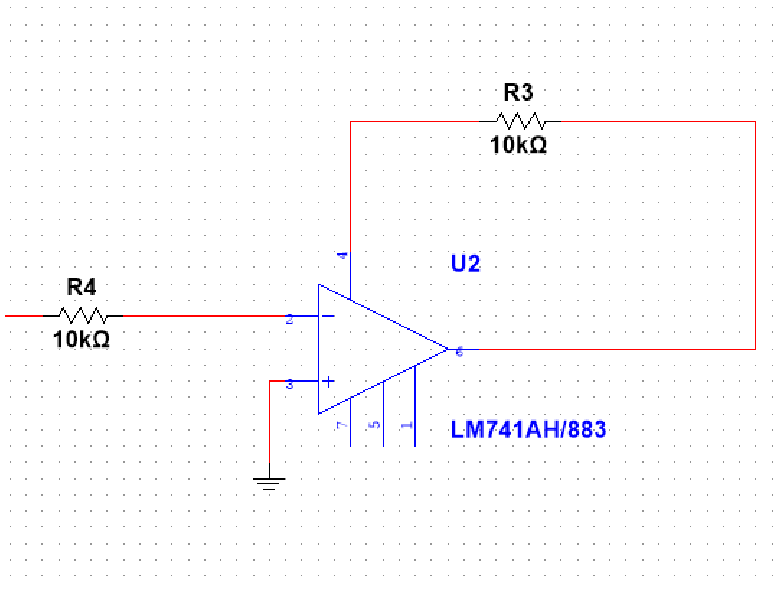

Figure 5: Part II

The code I used to obtain my Bode diagram is the following one:

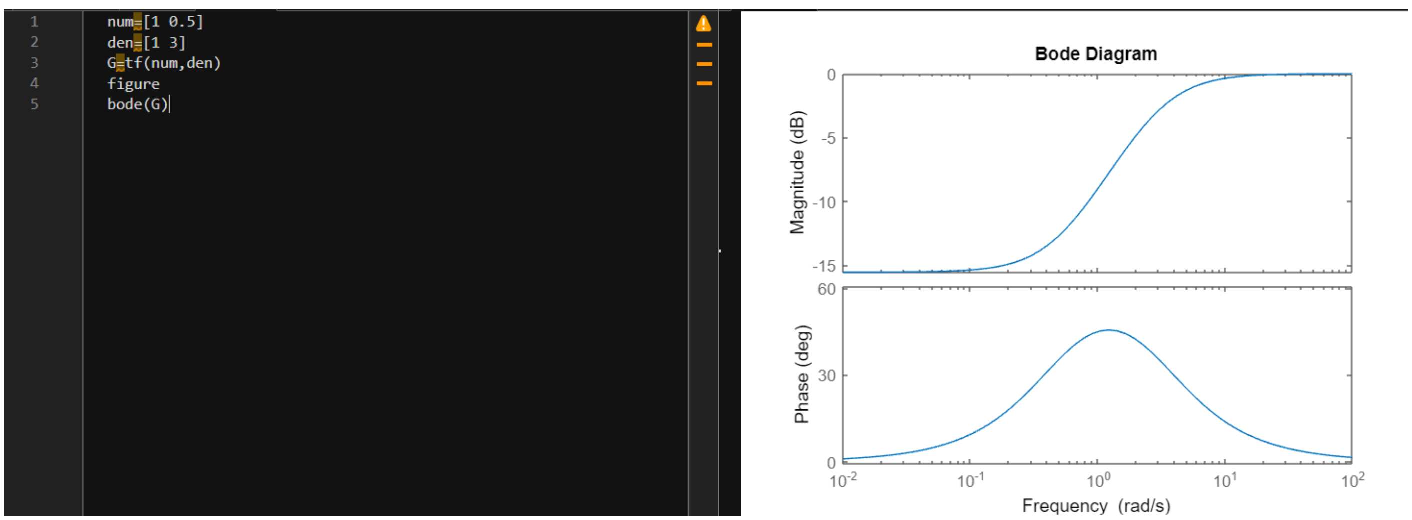

Figure 6: Part II

I used the Matlab software to graph my Bode diagram.

Conclusions

I was able to analyze the behaviour of the high pass filter. Calculate the values of my resistors and capacitors was a difficult process but at the end it was possible.

From this practice I understood the importance of the filters for taking care of our devices, by denying the pass of frequencies that can cause noise. Robotics engineers make use of this filters in telecommunications areas to regulate signals.

Understanding this filters is very important for life and specially for work in the life of an engineer.

References and Bibliography

Filtro electrónico. (s. f.). ingeniatic. Recuperado 4 de noviembre de 2022, de https://www.etsist.upm.es/estaticos/ingeniatic/index.php/tecnologias/item/456-filtro-electr%C3%B3nico.html