ISSN 2278-3091
Volume 9, No.4, July – August 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse251942020.pdf
https://doi.org/10.30534/ijatcse/2020/251942020

Development of Low Pass Filter Simulation Models

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ABSTRACT

The research will discuss the topic of the low-pass filter. The scope of the research will encompass data obtained throughout the experiment of the researchers, sample graphs of a low-pass filter, theory and background present, and analysis of data and results. Besides, the research will also look into a software program called Multisim to observe the behavior of a low-pass filter more accurately. This topic was chosen as this is the type of filter that the researchers are most familiar with. Furthermore, this type of filter was used in many audio applications in which it can eliminate background noise, remove specific frequencies in data analysis, radio tuning, and many more. Hence, this type of filter becomes known as high-cut or treble cut filters. This familiarity is a result of each group member's prior experience and studies throughout the course.

Key words: Low-Pass Filter, Cut-Off Frequency, RC Low-Pass Filters, RL Low-Pass Filters, Frequency Response.

1. INTRODUCTION

Low pass filters are filters that only accept low-frequency signals to pass through and blocks high-frequency signals [1]. Signals with low frequency are defined as frequency whose values are lower than the cut-off frequency [2]. Also, it separates input signals and either accepts or rejects the signals based on the value on frequency. Furthermore, it is composed of a resistor connected with either an inductor or a capacitor. Only two types of low pass filters are present and those are Inductive and Capacitive low pass filters [3,4].

The Capacitive filter is where a resistor and a voltage source have a series connection. The impedance across the capacitor is in an inverse relationship with the frequency whereas the impedance of the capacitor will decrease as the value of the frequency increases [5]. This means that the capacitor will have a high resistance towards low frequency thus blocking it from passing through the capacitor. It also has a low resistance towards high-frequency signals. High-frequency signals will pass through the capacitor because of its low resistance towards it and the capacitor will reject low-frequency signals. Therefore, it will pass through the output voltage. The capacitor tends to separate the high-frequency signals from the low-frequency signals because of its reactivity [6].

On the other hand, a low pass inductor filter is made up of an inductor in a series connection with the voltage source and a resistor connected in parallel with the voltage source just as shown in the figure above. The impedance of an inductor has a direct relationship with the frequency where the value of the impedance increases as the frequency increases. Due to its relationship with the frequency and its series connection with the voltage source, the inductor will block high-frequency signals from passing through and will only accept low-frequency signals [7].

2. BACKGROUND OF THE STUDY

Filters have been worked on as early as the 1890s when people such as Vaschy and Heaviside were working to improve the properties of long-distance transmission lines. The early stages of these filters were coils at regular intervals of transmission lines, and that a line containing these coils could be represented as an equivalent uniform cable instead. The coils had to be kept at these regular intervals. If they were separated too far or too close, then the line could not be represented as the same equivalent cable. With the help of these coils, Pupin found out that the dampening that occurs in telegraphy and telephony could be reduced. After this finding, the world then started to integrate 'Pupin lines' to their wires [8].

George A. Campbell further investigated the properties of these lines, finding that there was an effect exhibited by the wires that are frequency dependent. The frequency-dependent effect that Campbell found out was that there was a certain frequency wherein the damping characteristics would undergo a sudden change. Below this certain frequency the dampening was low, and above the same frequency, the dampening was high. This frequency was dependent on the distance between each coil, with an observable wavelength that is twice the distance from one coil to the other. This effect then helped with the problem of knowing how many coils to insert for every certain length of wire. Campbell himself noted that this was used to eliminate any kind of harmonics found in the waveform outputted from a signal generator. After the investigations of Campbell and Pupin, it was widely known that these wires required impedances and these impedances are combinations capacitances and inductances. These are now seen with the electrical filters today, commonly known as high-pass filters, low-pass filters, band-pass filters, and band-stop filters [9,10].

3. STATEMENT OF THE PROBLEM

In this world today, many things need to be filtered out of the system which can be people, food, and sounds. In the world of sounds, image processing, and electric sources, there are a lot of frequencies that can be manipulated and filtered out of the system to be able to create a better output in which the user needed [11]. Low-frequency noises can also negatively affect the people around them because people cannot hear anything below 2hz-200hz which is bad for health, and these can be found places around us, especially in speakers. Low frequency is really bad for audio because it is the noise that can make the sound quality very bad. To be able to counter these frequencies, a filter needed, and that filter is the low pass [12,13]. The research explaining the properties and traits of low pass filters in which it can help us produce better audio quality and image quality through the use of low pass signals.

4. SIGNIFICANCE OF THE STUDY

When people heard the word filter, the first thing that usually comes to mind is that it is a type of device used for removing unwanted impurities. Before the discovery of an audio filter exists, there are only a few limited ways to remove unwanted noise present from each device. However, since technology is growing rapidly throughout the years, several improvements in sound filtering have become recognizable. Users, even with the use of different devices, can now have better communications because of filters. The result of the study would benefit the following:

Students
The information presented will assist them to know the significance and characteristics of a low-pass filter just by collecting data, study the graphs presented, and analyzing the experiment provided by the researchers.

Educators
The results will help them deliver an extra channel of information or lectures by providing many more ways to further explain and prove the theory behind the topic. This will also help them reach out to different learners. For example, educators can use the graphical presentation to clarify a lecture instead of showing numeric tables. This could aid and motivate the students from learning more.

5. DESCRIPTION OF THE SYSTEM

The research done by the group is purely composed of simulations and research that provided aid in gaining more knowledge regarding the properties and applications of low pass filters. The researchers would not be able to test the low pass filter in digital and analog filters, especially related to audio amplifiers because of the limited equipment present in the laboratory.

6. METHODOLOGY

To obtain data for this research, the researchers read multiple articles about this type of filter and used data obtained from their experiment. The researchers also used the software Multisim to further explain low-pass filters graphically.

In the following sections, the researchers will be talking about articles that are relevant for this research, in which helped the researchers know more things about the topic and the software. The researchers will also be talking about the benefits of using the software because of the features that make it stand out.

7. DATA AND RESULTS

The numbers of data to be discussed in this research are based on the experiment that the researchers had done during the course. Figures 1, 2 and 3 shows the circuit connected by the researchers to obtain the measured values.

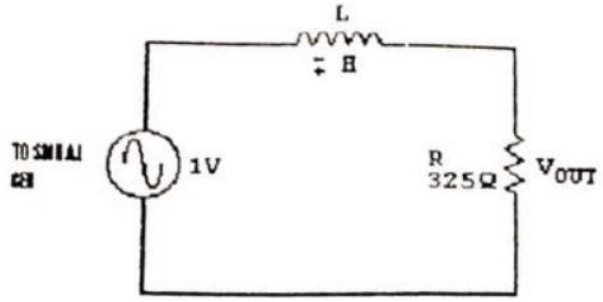

Figure 1: RC Low pass circuit

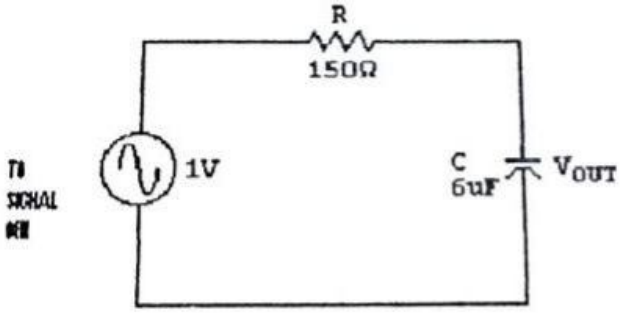

Figure 2: LC Low pass circuit

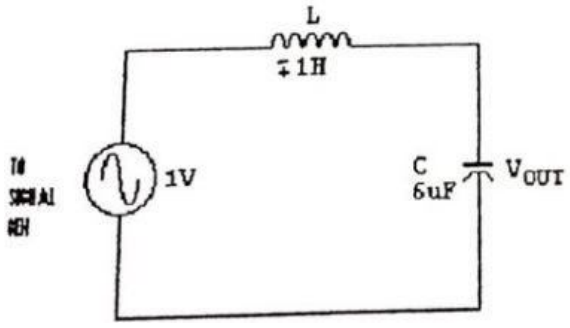

Figure 3: RC low-pass filter

Figures 4,5 and 6 shows the system simulations.

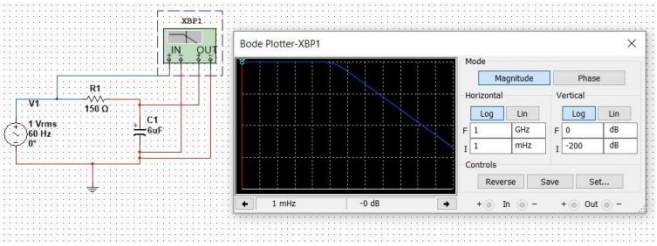

Figure 4: RC Low pass circuit simulation

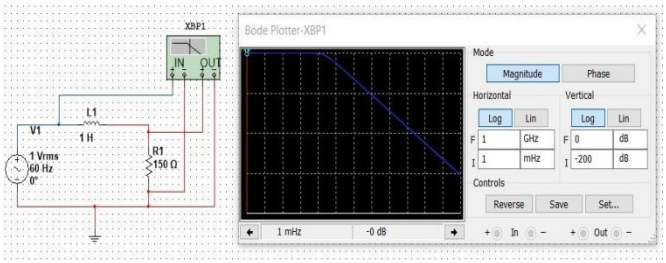

Figure 5: LC low-pass circuit simulation

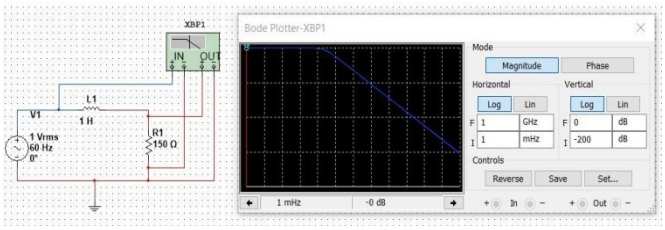

Figure 6: RC low-pass filter simulation

8. ANALYSIS OF DATA

Based on the data retrieved by the researchers, we know that low pass filters are filters that filter out the frequency that is equal to or higher than the cut-off frequency. This is made possible by connecting the load which can be a capacitor or a resistor to the ground.

The reason why capacitors that are parallel with the load resistor is a low pass filter is that if the frequency of the source increases the reactance of the capacitor decreases since the relationship of the reactance of the capacitor and the frequency is inverse. If the frequency of the source is equal to the cutoff frequency, the reactance will be very minute in which the capacitor can now act as a short circuit, in which all the high-frequency voltages will go there since that line has the least amount of resistance.

For the inductor, the inductor should be connected in series with the load resistor because as the user increases the frequency, the reactance of the inductor also increases to a certain where it acts as an open circuit which means, frequency higher than the cut off will be removed.

For the last circuit, the inductor is connected to the capacitor in series and that the load voltage will be taken from the capacitor. The circuit is set up this way because if the frequency is less than the cut off frequency, the inductor will act as a short circuit since the reactance is small, and that the capacitor will act like an open circuit where it can build up the voltage, which means the load can be taken from here.

Low pass filters are filters where they will only pass if the frequency is less than the cut off frequency in which the capacitor will be at its peak and an inductor goes to its lowest amount of reactance which can affect the behavior of the circuit. Inductors and capacitors are essential in filter circuits because of its potential to act as an open or shorted circuit at different frequencies.

9. CONCLUSION

Four types of filters are known and those are high pass, low pass, bandpass, and band stop. A low pass filter is a filter that accepts frequency signals lower than the cut-off frequency value and attenuates signals with values higher than the cut-off frequency. This filter also can consist of resistance, capacitance, and inductance but the simplest LPF can be made by connecting a single resistor and single capacitor in a series. It is used to remove unwanted high-frequency noise present in the system. Based on the data, the %V of frequencies higher than the cut-off frequency decreases drastically. This shows that the voltage of frequency signals lower than the cut-off is being passed while the voltage of frequency signals higher than the cut-off frequency is declining. In conclusion, the circuits given are all low pass filter since the voltage percentage of certain high frequency have reduced.

Furthermore, aside from blocking out voltages with frequencies that are less than the cut-off frequency, it blocks out the noise that could come from high-frequency signals. This in turn cleans out signals and allows for a cleaner signal for whatever needs to be processed. Low Pass Filters differ in function when active or passive. When using active low pass filters, it can act as an amplifier. As said by its use, active low pass filters can amplify output voltages by a certain factor, depending on the values of the components used. This is why low pass filters are commonly seen in appliances. Passive low pass filters can be usually seen in appliances such as subwoofers. A subwoofer is a sound device that reproduces low-pitched audio frequencies. These applications for low pass filters are commonly seen in day to day life. The use of low pass filters allows for high-frequency signals to be blocked out, and in turn, allows for specific purposes such as amplifiers.

10. RECOMMENDATION

The researchers recommend future researchers to be knowledgeable with the characteristics, behavior, and function of a low-pass filter. Once that is mastered, the person

can then fully analyze and understand the theory behind it and how a low-pass filter function. Eventually, one will be able to apply his/her knowledge in the physical world.

In addition to what was previously mentioned, the group recommends the future researchers to perform an experiment regarding low-pass filter with the use of oscilloscope and application such as Multisim. One must be familiar with the use of oscilloscope in order to study the graph and obtain measured results. On the other hand, with the use of Multisim, he/she will be able to obtain a more accurate result. After that he/she should also take time to compare and examine each of the computerized and measured results available to him/her in order to observe possible errors present in the experiment. It is not enough that one learns the characteristics of a low-pass filter through tables of data without observing the graph as well. By practicing what has been learned, one can have a deeper proficiency in analytical skills, understand the theory behind low-pass filter, not to mention a longer time of retention in the brain.

As a final recommendation, the group urges the future researchers to study the effects of cutoff frequency to the output voltage of a low-pass filter, study other types of filters, and know how to make a low-pass circuit using a resistor and capacitor. One must not limit their knowledge to what has been taught during the course as it will be significant for further review and later subjects.

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