University of Jeddah

Faculty of Engineering
Department of Electrical & Computer Engineering (ECE)

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Electronics - II (ECE 411)

Experiment No: 03

"Low Pass Filter Analysis using MultiSim"

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Introduction:

Filters of some sort are essential to the operation of most electronic circuits. It is therefore in the interest of anyone involved in electronic circuit design to have the ability to develop filter circuits capable of meeting a given set of specifications. Unfortunately, many in the electronics field are uncomfortable with the subject, whether due to a lack of familiarity with it, or a reluctance to grapple with the mathematics involved in a complex filter design.

In circuit theory, a filter is an electrical network that alters the amplitude and/or phase characteristics of a signal with respect to frequency. Ideally, a filter will not add new frequencies to the input signal, nor will it change the component frequencies of that signal, but it will change the relative amplitudes of the various frequency components and/or their phase relationships. Filters are often used in electronic systems to emphasize signals in certain frequency ranges. Such as filter has a gain which is dependent on signal frequency. As an example, consider a situation useful signal at frequency f_1 has been contaminated with an unwanted signal at f_2. If the contaminated signal is passed through a circuit shown in fig.1, that has very low gain at f_2 compared to f_1, the undesired signal can be removed, and the useful signal will remain.

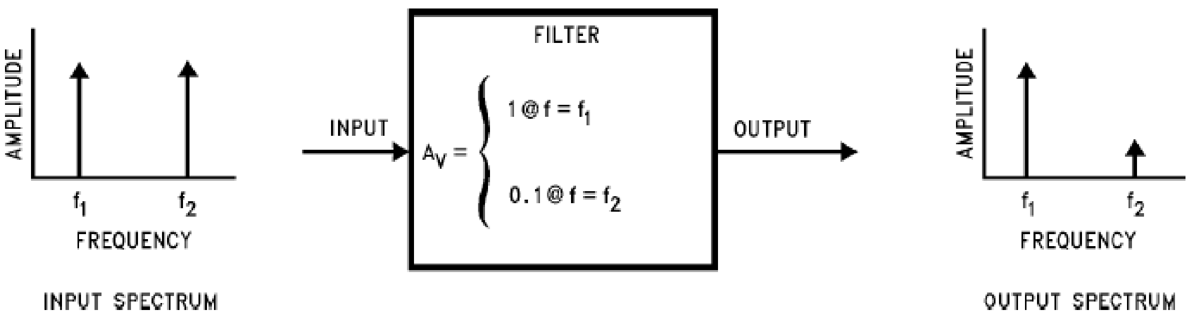

FIGURE 1. Using a Filter to Reduce the Effect of an Undesired Signal at Frequency f_2, while Retaining Desired Signal at Frequency f_1

Note that in the case of simple example, we are not concerned with the gain of the filter at any frequency other than f_1 and f_2. As long as f_2 is sufficiently attenuated relative to f_1, the performance of this filter will be satisfactory. In general, however, a filter's gain may be specified at several different frequencies, or over a band of frequencies. Since filters are defined by their frequency-domain effects on signals, it makes sense that the most useful analytical and graphical descriptions of filters also fall into the frequency domain. Thus, curves of gain vs. frequency and phase vs. frequency are commonly used to illustrate filter characteristics, and the most widely used mathematical tools are based in the frequency domain.

The frequency domain behavior of a filter is described mathematically in terms of its transfer function or network function. This is the ratio of the Laplace transforms of its output to the input signals. The voltage transfer function H(s) of a filter can therefore be written as:

$$H(s) = \frac{V_{Out}(s)}{V_{In}(s)}$$

Where $V_{in}(s)$ and $V_{out}(s)$ are the input and output signal voltages and '***s***' is the complex frequency variable.

The transfer function defines the filter's response to any arbitrary input signal, but we are most often concerned with its effect on continuous sine waves. Especially important is the magnitude of the transfer function as a function of frequency, which indicates the effect of the filter on the amplitudes of sinusoidal signals at various frequencies. Knowing the transfer function magnitude (or gain) at each frequency allows us to determine how well the filter can distinguish between signals at different frequencies. The transfer function magnitude vs. frequency is called the **Amplitude Response** or sometimes, especially in audio applications, the **Frequency Response**.

Similarly, the **Phase Response** of the filter gives the amount of **Phase Shift** introduced in sinusoidal signals as a function of frequency. Since a change in phase of a signal also represents a change in time, the phase characteristics of a filter become especially important when dealing with complex signals where the time relationships between signal components at different frequencies are critical.

A low pass filter passes low frequency signals, and rejects signals at frequencies above the filter's cutoff frequency.

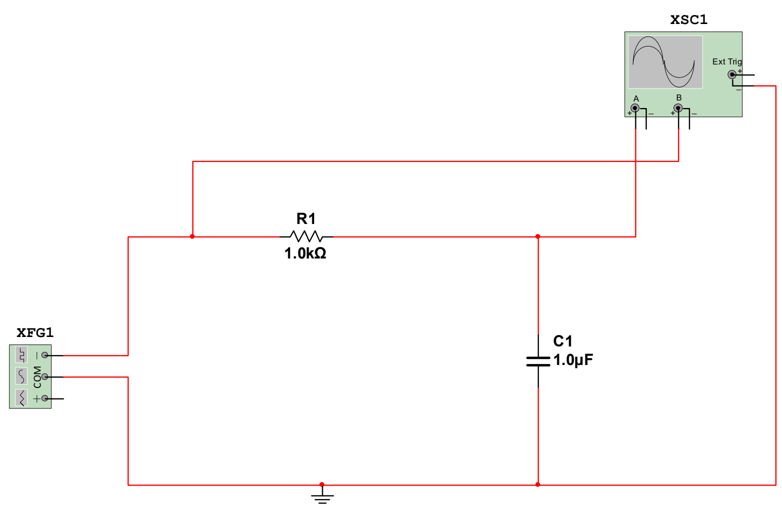

Fig. 2 A Low Pass Filter using MultiSim

Low pass filters are used whenever high frequency components must be removed from a signal. An example might be in a light sensing instrument using a photodiode. If light levels are low, the output of the photodiode could be very small, allowing it to be partially obscured by the noise of the sensor and its amplifier, whose spectrum can extend to very high frequencies. If a low pass filter is placed at the output of the amplifier, and if the cutoff frequency is high enough to allow the desired signal frequencies to pass, the overall noise level can be reduced.

Procedure:

- Draw the diagram as shown in fig. 2 in MultiSim.
- Connect the Function Generator.
- Connect Oscilloscope to check frequency gain/amplitude.
- Change frequency gain/value from function generator, and noted down its effect on oscilloscope.