BIRZEIT UNIVERSITY

Physics Department

Physics 112

Experiment #11

FILTERS

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Section:- 18

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Abstract:

1. **the aim of the experiment is:** is to see what is the filters and how do they works and to find the frequency of the band pass filters
2. **the method used:** is by connecting a filter circuits and read the data from the DSO screen to draw graphs that we can find the frequency of the band pass filters.

3. the main result is:

Low-pass filter:	**High-pass filter:**
$\omega_{-3dB} = 1.13 \times 10^4 \ rad/sec$	$\omega_{-3dB} = 1.01 \times 10^4 \ rad/sec$

$$\omega_{-3dB} = 1.0 \times 10^4 \, rad/sec \ (\textbf{Theoretically})$$

Low-pass filter acts as integrator when $f >> f_{-3dB}$ & High-pass filter acts as differentiator when $f << f_{-3dB}$

I. Theory:

Filters, in electronic circuits, are units used to allow only certain frequencies to pass through while others are blocked .The blocking occurs by means of reducing the amplitude of unwanted frequencies, which is known as *attenuation*, the attenuation factor (*A*) of a filter at a certain frequency is given by: $A = V_{out}/V_{in}$.

The two main types of filters are *low pass* and *high pass* filters. A low pass filter is shown in Fig. 1, in this type of filter low frequencies pass with virtually no attenuation (A≈1) while high frequencies experience high attenuation (A≈0). Quite the opposite occurs in a high pass filter as the one shown in Fig. 2, high frequencies pass with virtually no attenuation (A≈1) while low frequencies experience high attenuation (A≈0).

At the border between high and low attenuation for either type filter is an angular frequency known as ω_{-3dB} , practically, this angular frequency occurs when the amplitude of the output signal is 0.707 of the input amplitude, which means that $A = 1/\sqrt{2} = 0.707$,.
Experimentally ω_{-3dB} = $1/RC$

In the highly attenuated region of a low pass filter:
$V_R(t) = V_{in}(t) - V_{out}(t) \approx V_{in}(t)$

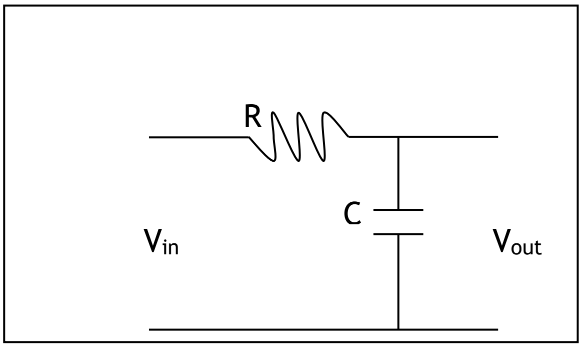
So: $I(t) = C\dfrac{dV_{out}(t)}{dt}$; $V_{in}(t) = RI(t) = RC\dfrac{dV_{out}(t)}{dt} \Rightarrow V_{out}(t) = \dfrac{1}{RC}\int V_{in}(t)dt$

This means that the filter is acting as an integrator for $\omega >> \omega_{-3dB}$.

Similarly, in the highly attenuated area of a high pass filter:

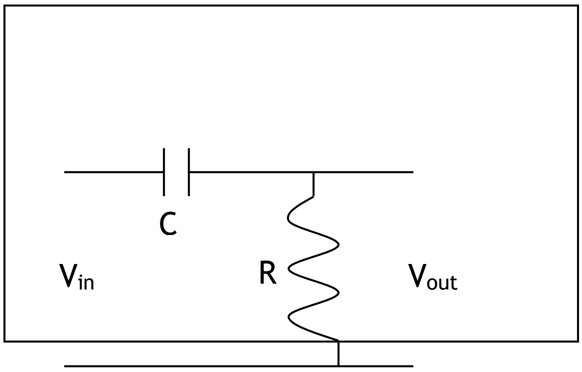
$V_c(t) = V_{in}(t) - V_{out}(t) \approx V_{in}(t)$

So: $I(t) = C\dfrac{dV_{in}(t)}{dt}$; $V_{out}(t) = RI(t) = RC\dfrac{dV_{in}(t)}{dt}$ This means that the filter is acting as a differentiator for $\omega << \omega_{-3dB}$.



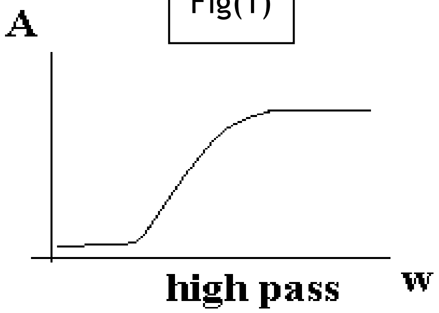
Fig(1)

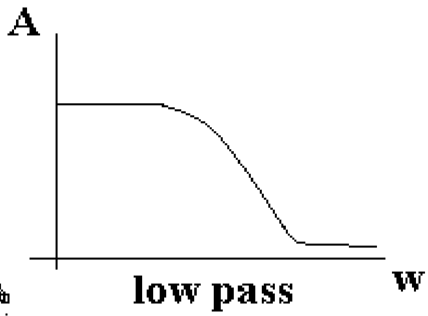
Fig(1)



Fig(2

Fig(2





Calculations:

- ω_{-3dB} Theoretically:

$$\omega_{-3dB} = \frac{1}{RC} = \frac{1}{(1\times10^{3}\Omega)(0.1\times10^{-6}F)} = 1.0\times10^{4}\, rad/\mathrm{sec}.$$

From the graphs:

Low-pass filter:

$\omega_{-3dB} = 2\pi f = 2\pi \times 1.8 \times 10^3 = 1.13 \times 10^4 \;\; rad/sec$

High-pass filter:

$\omega_{-3dB} = 2\pi f = 2\pi \times 1.6 \times 10^3 = 1.01 \times 10^4 \;\; rad/sec$

Results And Conclusion :

Exp. :

Low-pass filter:	**High-pass filter:**
$\omega_{-3dB} = 1.13 \times 10^4 \;\; rad/sec$	$\omega_{-3dB} = 1.01 \times 10^4 \;\; rad/sec$

Theo. :

$\omega_{-3dB} = 10^4 \;\; rad\ /sec$

when we look to the values we got from the experiment we find them acceptable in the range of the experiment's errors which comes from the OSC screen reading which has an 0.2 div uncertainty in the reading, and there is the power supply voltage which may change during the experiment which causes a systematic error in our values .This beside the resistivity of the wires we used in our exp. which make some error in our values .In fact , the values of ω_{-3dB}that we found was nearly close to each other and close to the theo. value of ω_{-3dB} ($10^4 \;\; rad\ /sec$) which means that the exp. was successful .

The value of ω_{-3dB} is represent the boundary between the frequency that highly attenuation and that ones that pass without any attenuation, and we mean by the attenuation that when we look to the amplitude of the signals that pass without any attenuation we find that its amplitude is large and almost have the same amplitude of the source, but if we look the amplitude to the ones that have attenuation on them we find that there amplitude is so small. And so the word attenuation means that decrease in amplitude

In the circuit that has an attenuation there is almost no voltage internal it and so there is no current in the circuit and here is the important of the filters (to block the current with unwanted frequencies) and so save the machines.

In the filters if we are in the area that there is a high attenuation, if the low pass filter is function then it will act as an integrator so:

If we put the sinusoidal wave from the source we will see that the out put voltage is also a sinusoidal wave because the integral of sine is minus cosine so it draw will be the same but with some phase different.
But if we but the tooth wave from the signal generator we will see that the output voltage graph will appear like parabola because the integration of a line equation like $(y = mx)$ is another equation for a parabola with equation of $(y = mx^2)$ as we can see in the graphs in data sheet. But if we put a square wave we will find that it is will appear like a tooth wave because the integration of the constant is a line equation $(y = mX)$.
On the other hand, if the high-pass filter is function in the high attenuation area it will act as a differentiator:
So if we put a sinusoidal wave it will derive the sine function to be a cosine function and this is what we see in the screen of the OSC, but if we but the tooth wave which has the equation of $(y = mX)$ we find that its derivative is constant so we will see it as a square wave. On the other hand if we put the square wave its derivative is infinite and minus infinite with zero between as in the figure.