X150994

UNIVERSITY OF NORTH CAROLINA At CHARLOTTE

Department of Electrical Engineering

Experiment No._________Filter Networks

INTRODUCTION

A filter network is one which discriminates between signal frequencies; i.e., it will allow signals of certain frequencies to pass through it while eliminating or drastically attenuating signals of other frequencies. There are three basic types of filter networks, known respectively as low-pass, high-pass, and bandpass filters. The ratio of the magnitude of the output signal to the input signal is known as the transfer function or gain of the network and is shown in Figures 1, 2, and 3 (on linear graph paper) as a function of frequency for the respective filters. The phase relationship between the input and output signals is also an important parameter of a filter network and is often included on the magnitude plot. The frequencies, fl and fu, are the half-power frequencies or sometimes called lower and upper break or cutoff frequencies.

Filter networks are made up of inductors, capacitors and resistors in various combinations and configurations. The networks can become quite complex in design depending on their desired features.

It should also be stressed that the load on the output of a filter network can affect its frequency response and should be included in the analysis if this is the case.
The simple L-type filter network will be investigated in this experiment.

PRELIMINARY

P-1. Derive the voltage transfer functions for the networks in Figures 4 and 5 in terms of R, C, and f (Hertz).

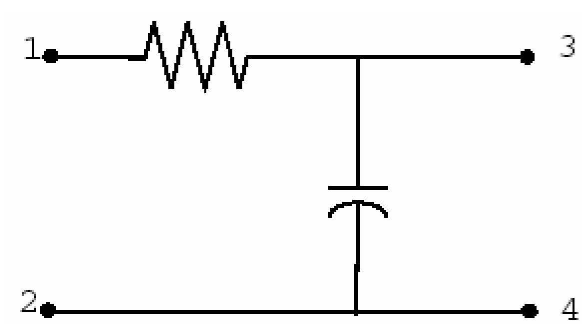


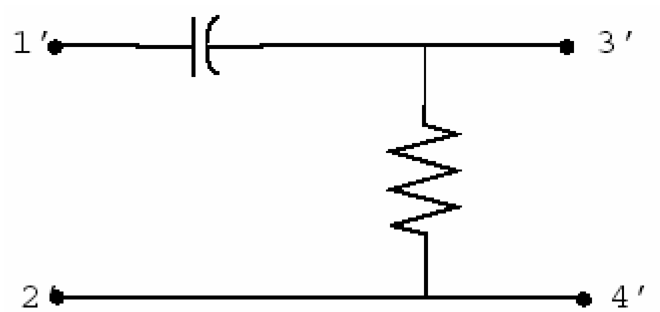
FIG 4:
Vi = input voltage across points 1 and 2
Vo = output voltage across points 3 and 4
Transfer function across the capacitor : 1/ sC

$$Vo = \frac{(1/sC).Vi}{R + 1/sC} = \frac{Vi}{1 + sRC} \qquad s = j\omega = j2\pi f$$

$$Vo/Vi = \frac{1}{1 + j2\pi fRC}$$

LPF : f_B at $f = 1/2\pi RC$

FIG 5:



Vi = input voltage across points 1' and 2'
Vo = output voltage across points 3' and 4'
Transfer function across the capacitor : 1/ sC

$$Vo = \frac{RVi}{R+1/sC} = \frac{sRCVi}{1+sRC}$$

$$Vo/Vi = \frac{j2\pi fRC}{1+j2\pi fRC}$$

HPF : f_B at $f = 1/2\pi RC$

P-2. Using MATLAB, obtain a plot of the voltage transfer function for the network in Figure 4 as a function of frequency, f, using a log-log scale. Assume R = 600 ohms and C = 6.6 nanofarads. From the plot, identify the network as to whether it is a low-pass, high-pass, or bandpass filter network and determine the break frequency (frequencies)

LPF:

$f_B \approx 40.2$ KHZ

$$Vo/Vi = \frac{1}{1+j2\pi f(600)(6.6 \times 10^{-9})}$$

$$\approx \frac{1}{1 + j2.486 \times 10^{-5} f}$$

P-3. Repeat P-2 above assuming R = 600 ohms and C = 2.7 nanofarads.

$f_B \approx 98.2$ KHZ

$$\approx \frac{1}{1+ j\, 1.018 \times 10^{-5} f}$$

P-4 Repeat P-2 above assuming R = 600 ohms and C = 26.5 nanofarads for the network in Figure 5.

$f_B \approx 10$ KHZ

$$\approx \frac{j\, 9.99 \times 10^{-5} f}{1 + j\, 9.99 \times 10^{-5} f}$$

P-5 Obtain a plot of the product of the transfer functions used in P-2 and P-4 above on a log-log scale using MATLAB. Identify the break frequency (frequencies).

$$Vo/Vi = \frac{1}{1+ sR_1C_1} \cdot \frac{1}{1 + sR_2C_2}$$

$f_{B1} = 40$ KHZ

$f_{B2} = 10$ KHZ

P-6. Plot the product of the transfer functions used in P-3 and P-4 above on the fifth sheet of log-log paper. Identify the break frequency (frequencies).

P-7. Repeat P-5 above using PSPICE.

P-8. Repeat P-6 above using PSPICE.

INSTRUCTOR'S SIGNATURE______________________________DATE__________

SUGGESTED REFERENCE

MICROELECTRONIC CIRCUITS
Adel S.Sedra and Kenneth C.Smith(Third edition)
Chapter 11: Filters and Tuned Amplifiers

PROCEDURE

F-1. Connect the network of Figure 4 to the signal source as shown in Figure 6 using the element values specified in P-2 above.Using a dueL-trace oscilloscope, measure the peak-to-peak value of the output voltage over a frequency range of from one-tenth of the break frequency to ten times the break frequency for a low-pass or a high-pass filter network and one-tenth of the lower break frequency to ten times the upper break frequency for a bandpass filter network. Maintain the input voltage at 10 volts peak-to-peak.

F-2. Repeat F-1 above for the network of Figure 4 using the element values specified in P-3 above.

F-3. Repeat F-1 above for the network of Figure 5 using the element values specified in P-4 above.

F-4. Connect the networks of Figure 4 and Figure 5 as shown in Figure 7. Use the element values specified in P-2 and P-4 above for the respective networks. Measure the output voltage over the frequency range specified in F-1 above. Maintain the input voltage at 10 volts peak-to-peak.

F-5. Repeat F-4 above using element values specified in P-3 and P-4 above for the respective networks.

<u>REPORT</u> (should include at least the following)

R-1. Plot five to eight experimental data points on the respective graphs obtained from the simulations in the Preliminary exercise (F-1 and P-2, F-2 and P-3, F-3 and P-4, F-4 and P-5,F-5 and P-6, F-4 and P-7, and F-5 and P-8). Be sure to include data at the break points.

R-2. Discuss the frequency response curves and explain any major differences between the experimental and calculated data.

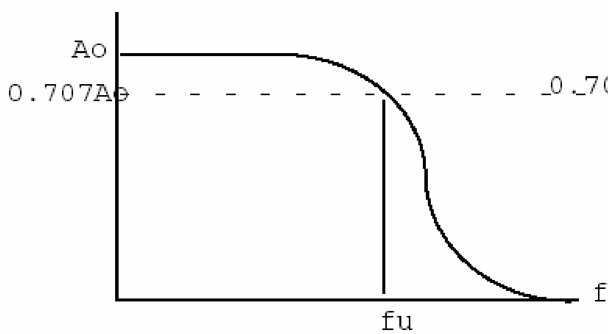


Figure 1. Frequency Response of a Low-pass Filter

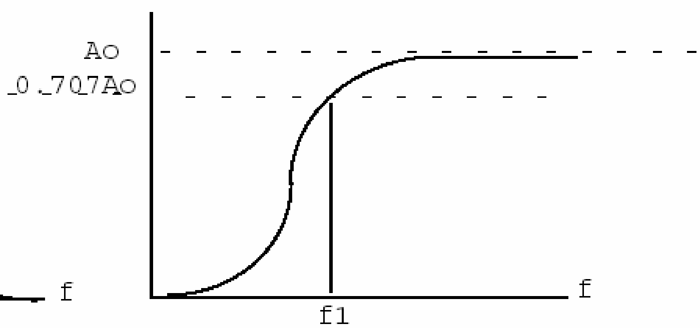


Figure 2. Frequency Response of a High-pass Filter

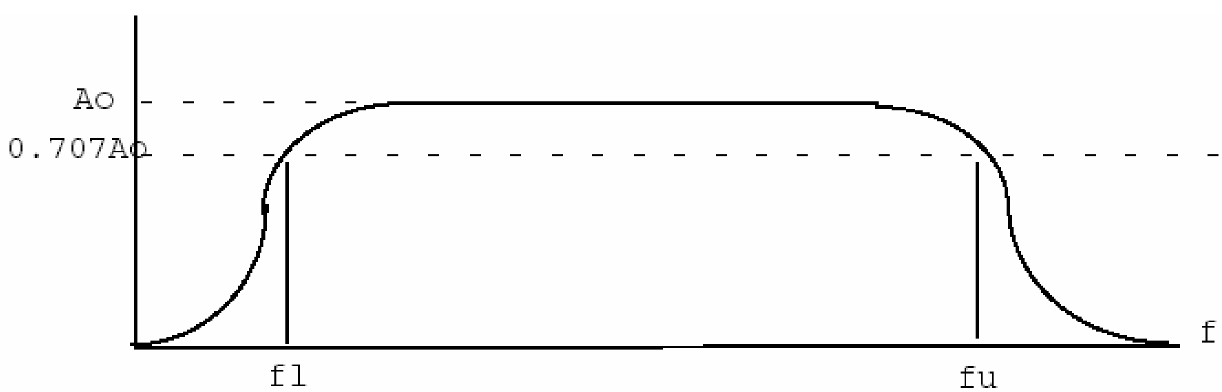


Figure 3. Frequency Response of a Band-pass Filter

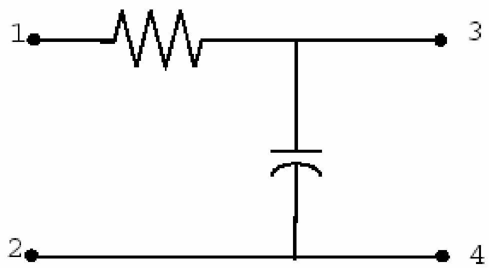


Figure 4. Network #1

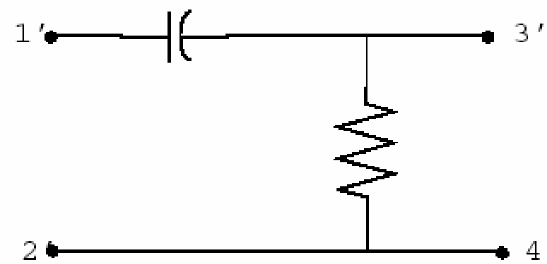


Figure 5. Network #2

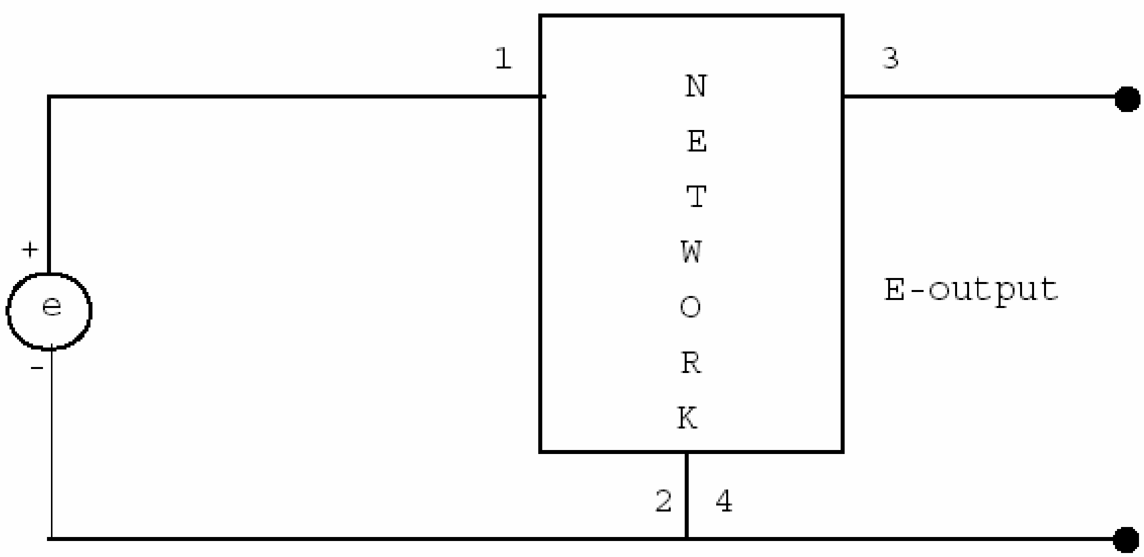


Figure 6.

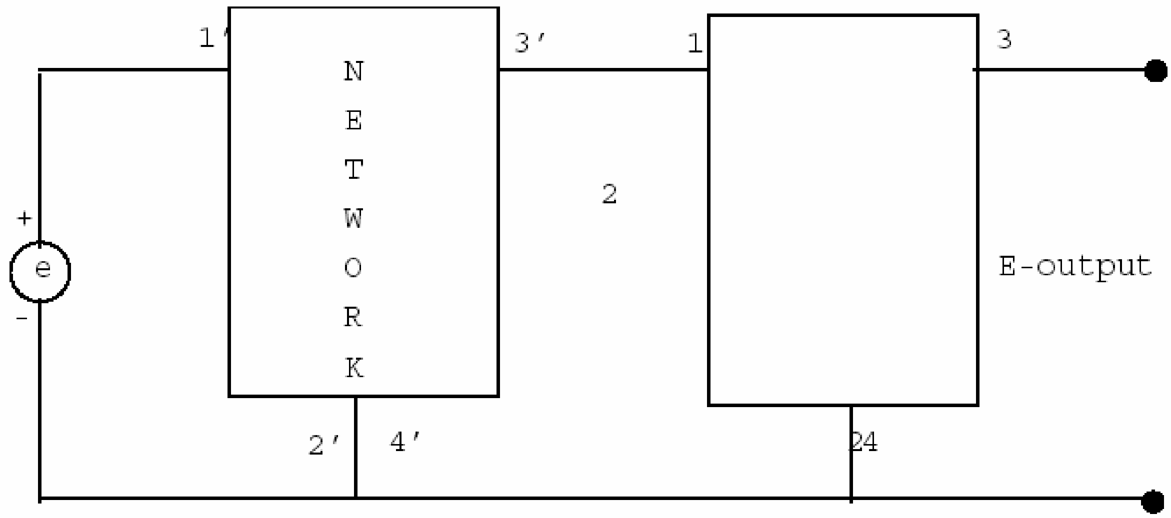


Figure 7.