EEEN 202 ELECTRICAL AND ELECTRONIC CIRCUITS II

EXPERIMENT 5: EXAMINATION OF ACTIVE FILTERS

INTRODUCTION

The circuits that process the electrical signals according to their frequency content are called filters. The filters are classified in four groups:

1. **Low pass filter:** They are the filters that allow the signals below a frequency to pass and over that frequency to stop.
2. **High pass filter:** They are the filters that allow the signals over a frequency to pass and below that frequency to stop.
3. **Band pass filter:** They are the filters that allow the signals between a frequency range to pass and out of that frequency range to stop.
4. **Band stop filter:** They are the filters that make the signals between a frequency range to stop and out of that frequency range to pass.

In order to select a frequency band, more than one filter can be connected one after the other. By that way, more sensitive filters can be obtained. The number of filters connected one after another determines the degree of the filter. The quality of the filter increases with the increasing degree.

Filters are analyzed in two groups according to the type of elements used:

Passive filters: They are the filters constructed by inductors or capacitors. The operation of that type of filters depends on the fact that the reactance of inductors and capacitors change with the frequency. As we know;

$$X_L = 2\pi f_L$$

$$X_C = \frac{1}{2\pi f_C}$$

Passive filters attenuate the signal even the frequency is in the pass band.

Active filters: They are the filters constructed by elements that have amplification property (transistors, operational amplifiers). The active filters choose the pass frequency band by using resistance and capacitors (without using inductors).

If we compare active and passive filters;

1. Passive filters do not need voltage supply. Active filters use voltage supply.

2. The frequency band of the passive filters is wide. They are used at high frequencies. The frequency band of the active filters is narrow. So, they are not used at high frequencies.
3. The fabrication of the active filters is simple and cheap because they do not need inductor.
4. The active filters can amplify signals in the frequency band. Passive filters attenuate these signals a little bit.
5. The input impedance of the active filter is high. So, they do not affect the signal source.

ANALYZING OPERATIONAL AMPLIFIER OPERATING AS LOW PASS ACTIVE FILTER

A second degree low pass active filter constructed by operational amplifier is given in Figure 5.1.

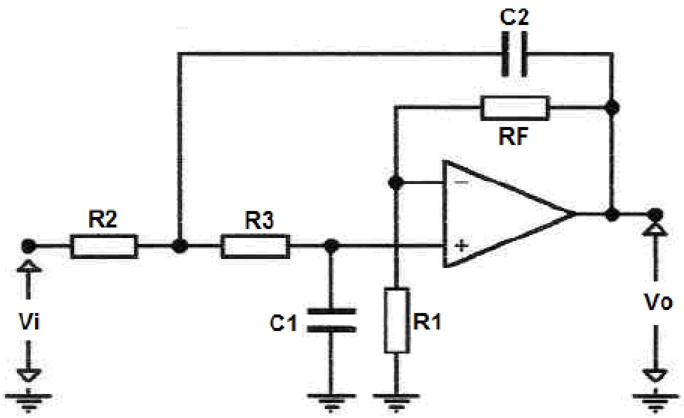

Figure 5.1

The first filter operation is performed by R2- C1 and the second filter operation is performed by R3-C2. The operational amplifier operates as a non-inverting amplifier. Since the gain of the noninverting amplifier is greater than 1, the input signal is not attenuated. For low pass active filters, the gain of the circuit must be 1,58 in order to have linear frequency characteristic in the pass band. The gain of the inverting amplifier is;

$$A = 1 + \frac{RF}{R1}$$

where $\frac{RF}{R1} = 0.58$

In our experiment, let the resistances be selected as RF=5,6K and R1=10K. So, the ratio is 0,56. The frequency at which the gain of the circuit is 1 is called cut-off frequency. If we show the cut-off frequency by (**fc**);

$$fc = \frac{1}{2\pi\sqrt{R2 \cdot C1 \cdot R3 \cdot C2}}$$

In the applications, the elements are selected as R2=R3 and C1=C2. So, the cut-off frequency is;

$$fc = \frac{1}{2\pi R2 \cdot C1}$$

The gain of the low pass active filter is 1,58 for frequencies smaller than the cut-off frequency. The gain decreases with the increasing frequency over the cut-off frequency.

ANALYZING OPERATIONAL AMPLIFIER OPERATING AS HIGH PASS ACTIVE FILTER

A second degree high pass active filter constructed by operational amplifier is given in Figure 5.2. As it is seen, the capacitors and the resistors in the low pass active filter are exchanged. The first filter operation is performed by C1-R2 and the second filter operation is performed by C2-R3.

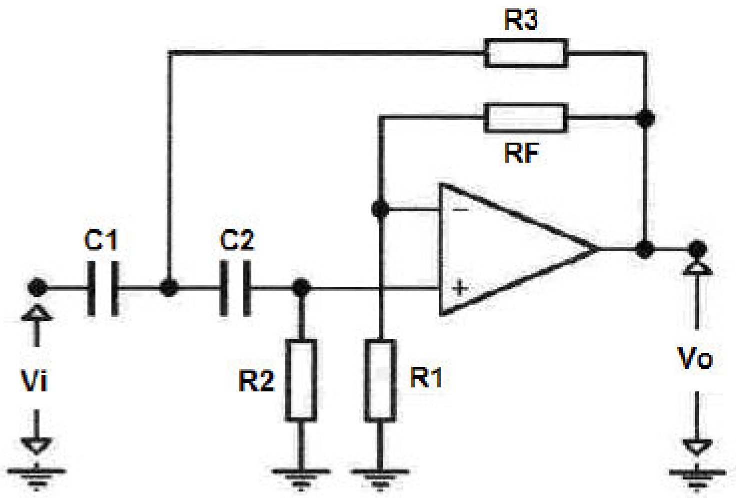

Figure 5.2

The operational amplifier operates as a non-inverting amplifier. Since the gain of the non-inverting amplifier is greater than 1, the input signal is not attenuated. For high pass active filters, in order to have linear frequency characteristic in the pass band, the resistances should be selected in a way that $\frac{RF}{R1} = 0.58$ (to have a gain $A = 1 + \frac{RF}{R1} = 1.58$).

In our experiment, let the resistances be selected as RF=5,6K and R1=10K. So, the ratio is 0,56.

The frequency at which the gain of the circuit is 1 is called cut-off frequency. If we show the cut-off frequency by (**fc**);

$$fc = \frac{1}{2\pi\sqrt{C1 \cdot R2 \cdot C2 \cdot R3}}$$

In the applications, the elements are selected as R1=R2 and C1=C2. So, the cut-off frequency is;

$$fc = \frac{1}{2\pi C1 \cdot R2}$$

The gain of the high pass active filter is 1,58 for frequencies greater than the cut-off frequency. The gain decreases with the decreasing frequency under the cut-off frequency.

EXPERIMENT 5.1 EXAMINATION OF LOW PASS ACTIVE FILTER

EXPERIMENTAL PROCEDURE:

Connect the circuit as shown in Figure 5.3.

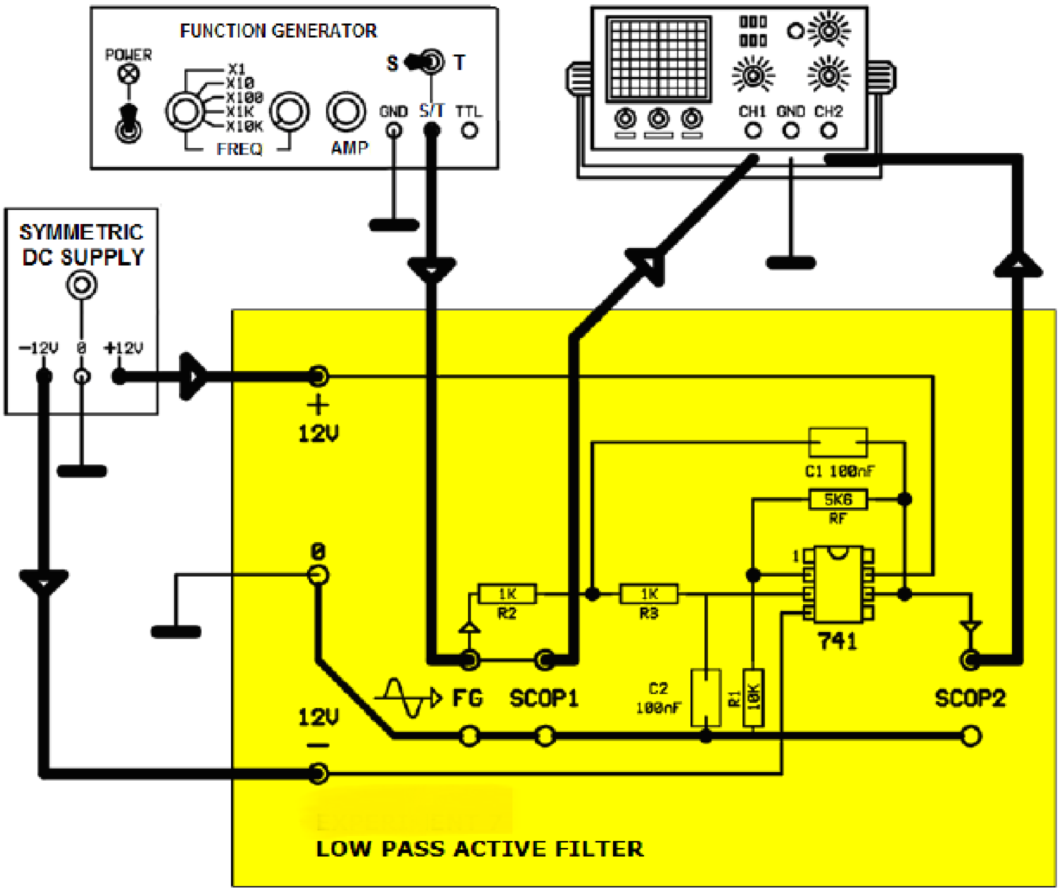

Figure 5.3

1. Apply power to the circuit. By using scope1, set the output of the function generator to sine with amplitude 1Vpp and with frequency given in Table 1 for each step. Take note of the output signal amplitude in each step.

Table 5.1

Vi = 1Volt (pp)		
f (Hertz)	**Vo (Volt)**	**A**
100		
200		
500		
1000		
1200		
1400		
1600		
1800		
2000		
5000		
10000		

2. Calculate the cut-off frequency if R2=R3=1K and C1=C2=100nf.

3. Is the calculated cut-off frequency close to the experimental results?

4. Plot the frequency-gain graph according to the values in Table 5.1.

5. Calculate the frequency band of the circuit.

EXPERIMENT 5.2 EXAMINATION OF ACTIVE HIGH PASS FILTER

The preliminary information has been given above.

EXPERIMENTAL PROCEDURE:

Connect the circuit as shown in Figure 5.4.

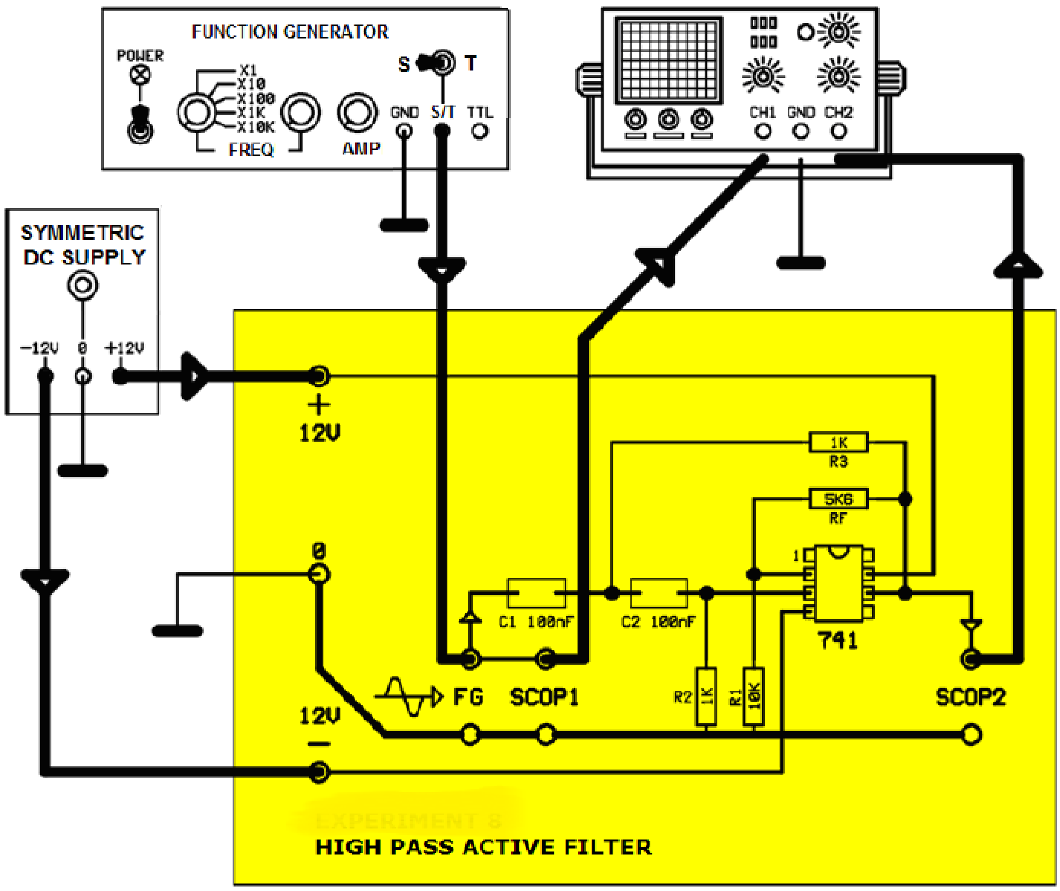

Figure 5.4

1. Calculate the cut-off frequency if R2=R3=1K and C1=C2=100nf.

2. Apply power to the circuit. By using scope1, set the output of the function generator to sine with amplitude 1Vpp and with frequency given in Table 1 for each step. Take note of the output signal amplitude in each step.

Table 5.2

Vi = 1Volt (pp)		
f (Hertz)	**Vo (Volt)**	**A**
100		
200		
500		
1000		
1200		
1400		
1600		
1800		
2000		
3000		
4000		
5000		
10000		

3. Is the calculated cut-off frequency close to the experimental results?

4. Plot the frequency-gain graph according to the values in Table 5.1.

5. Calculate the frequency band of the circuit.