Passive High-Pass Filter

Jaeho Cho
ECE444 - Bioinstrumentation and Sensing
The Cooper Union for the Advancement of Science and Art
New York City, NY
jaeho.cho@cooper.edu

***Abstract*—**

***Index Terms*—**

I. Introduction

II. Methodology

A. Design Process

From "Table A-1 Element values for low-pass single-resistance-terminated lossless-ladder realizations" in *Introduction to the Theory and Design of Active Filters* [1], the following values are given for a 3rd-order butterworth low-pass filter with a 1 rad/s bandwidth terminated with a resistance of $R = 1\Omega$:

$$\begin{aligned} L_1 &= 1.5000 \\ C_2 &= 1.3334 \\ L_3 &= 0.5000 \end{aligned} \tag{1}$$

To transform the low-pass filter into a high-pass filter, the inductors become capacitors with $C = 1/L$ and the capacitors become inductors with $L = 1/C$. The values for the high-pass filter are thus:

$$\begin{aligned} C_1' &= \frac{1}{L_1} = 0.6667 \\ L_2' &= \frac{1}{C_2} = 0.7500 \\ C_3' &= \frac{1}{L_3} = 2.0000 \end{aligned} \tag{2}$$

To denormalize the filter such that the cutoff frequency is $f_c = 1$ kHz or $\omega_c = 2\pi f_c = 3141.59$ rad/s and with a load resistance of $R_L = 1\,\text{k}\Omega$, the component values should be scaled accordingly:

$$\begin{aligned} C_1'' &= \frac{C_1'}{R\omega_c} = 106.10\ \text{nF} \\ L_2'' &= \frac{RL_2'}{\omega_c} = 119.37\ \text{mH} \\ C_3'' &= \frac{C_3'}{R\omega_c} = 318.31\ \text{nF} \end{aligned} \tag{3}$$

TABLE I: Component Values

Component	Ideal	Measured
C_1	106.10 nF	93.9543 nF
C_2	318.31 nF	354.231 nF
L_{11}	NA	68.5271 mH
L_{12}	NA	75.4791 mH
L_1	119.37 mH	225.395 mH
R_{ind}	0 Ω	104.016 Ω
R_L	1 kΩ	0.99853 kΩ

B. Experimental Setup

III. Results and Discussion

A. 4.1 Frequency Response

TABLE II: Measured Frequency Response Values

Frequency	V_in	V_out	Linear_Gain	dB_Gain
2	5.11	0.11	0.02	-33.34
3	5.11	0.11	0.02	-33.34
4	5.11	0.11	0.02	-33.34
5	5.11	0.11	0.02	-33.34
6	5.11	0.11	0.02	-33.34
7	5.11	0.11	0.02	-33.34
8	5.11	0.11	0.02	-33.34
9	5.11	0.11	0.02	-33.34
10	5.11	0.11	0.02	-33.34
20	5.11	0.11	0.02	-33.34
30	5.11	0.11	0.02	-33.34
40	5.11	0.11	0.02	-33.34
50	5.11	0.11	0.02	-33.34
60	5.11	0.11	0.02	-33.34
70	5.11	0.11	0.02	-33.34
80	5.11	0.11	0.02	-33.34
90	5.11	0.11	0.02	-33.34
100	5.11	0.11	0.02	-33.34
200	5.11	0.16	0.03	-30.09

Frequency	V_in	V_out	Linear_Gain	dB_Gain
300	5.11	0.26	0.05	-25.87
400	5.11	0.46	0.09	-20.91
500	5.11	0.76	0.15	-16.55
600	5.07	1.14	0.22	-12.96
700	5.03	1.61	0.32	-9.89
800	5.03	2.07	0.41	-7.71
900	5.03	2.51	0.5	-6.04
1000	4.98	2.91	0.58	-4.67
2000	4.86	4.34	0.89	-0.98
3000	4.86	4.58	0.94	-0.52
4000	4.86	4.66	0.96	-0.37
5000	4.86	4.7	0.97	-0.29
6000	4.86	4.74	0.98	-0.22
7000	4.86	4.74	0.98	-0.22
8000	4.86	4.78	0.98	-0.14
9000	4.86	4.78	0.98	-0.14
10000	4.86	4.78	0.98	-0.14
20000	4.86	4.78	0.98	-0.14
30000	4.86	4.78	0.98	-0.14
40000	4.86	4.78	0.98	-0.14
50000	4.86	4.74	0.98	-0.22
60000	4.86	4.74	0.98	-0.22
70000	4.86	4.74	0.98	-0.22
80000	4.86	4.7	0.97	-0.29
90000	4.86	4.7	0.97	-0.29
100000	4.86	4.7	0.97	-0.29
200000	4.86	4.62	0.95	-0.44
300000	4.86	4.62	0.95	-0.44
400000	4.86	4.62	0.95	-0.44
500000	4.86	4.62	0.95	-0.44
600000	4.82	4.62	0.96	-0.37
700000	4.78	4.62	0.97	-0.3
800000	4.78	4.62	0.97	-0.3
900000	4.78	4.62	0.97	-0.3
1000000	4.78	4.62	0.97	-0.3
2000000	4.54	4.54	1	0
3000000	4.22	4.46	1.06	0.48
4000000	3.82	4.38	1.15	1.19
5000000	3.5	4.3	1.23	1.79
6000000	3.18	4.3	1.35	2.62
7000000	2.93	4.22	1.44	3.17
8000000	2.69	4.22	1.57	3.91
9000000	2.5	4.23	1.69	4.57
10000000	2.34	4.23	1.81	5.14
20000000	1.36	4.31	3.17	10.02

This paper demonstrates the feasibility and effectiveness of a passive high-pass filter using two capacitors and a single inductor. The filter achieved predictable behavior with a sharp cutoff near the designed frequency and negligible attenuation in the passband. The configuration is suitable for applications requiring compact, passive high-frequency filtration with minimal component count.

IV. Discussion

- The table showed certain values
- To get the proper corner frequency, how did you apply a frequency denormalization?
- To get your inductor value, what impedance denormalization did you apply?
- What component values did that give you?
- What components were you able to find? Did that make you go back and redo the impedance denormalization?

References

[1] L. P. Huelsman and P. E. Allen, *Introduction to the Theory and Design of Active Filters*. New York: McGraw-Hill, 1980.