First Order Low Pass Active Filter

Specifications

Non Inverting DC Gain 20dB

3dB Frequency $f_{\text{crit}}$

$$K := \frac{20}{20} = 10 \quad \text{Pick} \quad C := 0.1 \mu F \quad \text{Pick} \quad R_B = 3 \Omega \quad R_A = 27 \Omega$$

$$T(s) = K \cdot \frac{1}{1 + \frac{s}{\tau}} \quad \tau = RC$$

$$K = T(0) \quad f_3 = \frac{1}{2\pi \tau}$$

$$f_3 := f_{\text{crit}}$$

$$R := \frac{1}{2\pi f_3 C} = 154.82 \Omega$$

$$K = 1 + \frac{R_A}{R_B} \quad T(f) := K \cdot \frac{1}{1 + \frac{f}{f_3}}$$

Graph showing the $20 \log |T(f)|$ and $\frac{180}{\pi} \arg(T(f))$ against frequency $f$. The graph includes a curve for $20 \log |T(f)|$ and a dashed line for $\frac{180}{\pi} \arg(T(f))$.
First Order

LPF_1st_Order
AC Analysis

Magnitude

Frequency (Hz)

Phase (deg)

502.82 \Omega
C 0.1 \mu F
RA 27k \Omega
RB 3k \Omega
Vo

(1.0587k, 19.9542dB)
(10.2800k, 16.9897dB)
Low Pass Shelfving Filter

\[ j := \sqrt{-1} \quad \text{f}_{\text{crit}} := 10.28 \text{kHz} \]

\[ T(s) = K \frac{1 + s\tau_z}{1 + s\tau_p} \]

\[ T(0) = K = 1 + \frac{R_{F1} + R_{F2}}{R} \]

\[ T(\infty) = 1 + \frac{R_{F1}}{R} \]

\[ \tau_p = R_{F2}C \]

\[ \tau_z = \left[ R_{F2} \parallel (R_{F1} + R) \right]C \]

Specification

\[ f_p := f_{\text{crit}} \quad \text{DC gain} \quad 20\text{dB} \]

\[ \infty \text{ frequency gain} \quad 6\text{dB} \]

Solution

Pick \[ C := 0.015\mu\text{F} \]

\[ \tau_p := \frac{1}{2\pi f_p} \quad R_{F2} := \frac{\tau_p}{C} = 1.032\text{k}\Omega \]

\[ K := 10^{20} = 10 \quad K_H := 10^{20} = 1.995 \]

\[ R := \frac{R_{F2}}{K - K_H} = 128.94\Omega \]

\[ R_{F1} := R \left( K_H - 1 \right) = 128.329\Omega \]

\[ \tau_z := \frac{K_H}{K} \tau_p \quad f_z := \frac{1}{2\pi \tau_z} \]

\[ 1 + j \frac{f}{f_z} \]

\[ T(f) := K \frac{f_z}{1 + j \frac{f}{f_p}} \]

\[ 20 \cdot \log |T(f)| \]

\[ \text{arg}(T(f)) = 180^\circ \]

\[ -30^\circ \]

\[ -40^\circ \]

\[ -50^\circ \]

\[ 0 \]

\[ 1 \times 10^3 \]

\[ 1 \times 10^4 \]

\[ 1 \times 10^5 \]

\[ 1 \times 10^6 \]
Low Pass Shelving Filter
High Pass Shelveing Filter

\( j := \sqrt{-1} \quad f_{\text{crit}} := 10.28 \text{kHz} \)

\[ T(s) = K \frac{1 + s\tau_z}{1 + s\tau_p} \]

\[ T(0) = K = \frac{-R_F}{R_1 + R_2} \]

\[ T(\infty) = \frac{-R_F}{R_1} \quad \tau_z = R_2 C \]

\[ \tau_p = (R_2 \| R_1) C \]

\[ f_p = \frac{1}{2\pi \cdot \tau_p} \quad f_z = \frac{1}{2\pi \cdot \tau_z} \]

**Specification**

- \( f_z = f_{\text{crit}} \)
- DC gain: 6dB
- Infinite frequency gain: 20dB

**Solution**

Pick \( C := 0.015 \mu\text{F} \)

\[ \tau_z := \frac{1}{2\pi f_z} \]

\[ R_2 := \frac{\tau_z}{C} = 1.032 \text{k}\Omega \]

\[ K := -(10)^{20} = -1.995 \quad K_H := -10^{20} = -10 \]

\[ R_F := \frac{R_2}{K H} = 2.573 \text{k}\Omega \]

\[ R_1 := \frac{-R_F}{K H} = 257.27 \Omega \]

\[ \tau_p := \frac{K}{K H} \cdot \tau_z \quad f_p := \frac{1}{2\pi \cdot \tau_p} \]

\[ f_p = 51.522 \text{kHz} \]

\[ T(f) := K \frac{1 + j f}{f_z} \]

\[ 20 \log |T(f)| \]

\[ \arg T(f) \]

\[ \tau_z = \frac{1}{2\pi f_z} \]

\[ \tau_p = \frac{1}{2\pi f_p} \]

\[ f_z = \frac{1}{2\pi \tau_z} \]

\[ f_p = \frac{1}{2\pi \tau_p} \]

\[ f = 1 \times 10^3 \quad 1 \times 10^6 \]

\[ 0 \quad 30 \quad -10 \quad -140 \quad -180 \]

\[ 20 \quad 150 \quad 180 \quad \pi \quad \text{rad} \]
High Pass Shelving Filter
First Order All Pass Filter Inverting Phase

\[ j := \sqrt{-1} \]

\[ T(s) = K \frac{1 - s\tau}{1 + s\tau} \]

\[ K = 1 \quad \tau = RC \]

Frequency at which phase shift is -90 degrees

\[ f_0 = \frac{1}{2\pi \tau} \]

Specification

\[ f_{\text{crit}} := 10.28 \text{kHz} \]

\[ f_o := f_{\text{crit}} \]

Pick \( C := 0.015 \mu\text{F} \)

\[ K := 1 \]

\[ R := \frac{1}{2\pi C f_o} = 1.032 \text{k}\Omega \]

\[ T(f) := K \frac{1 - j\frac{f}{f_o}}{1 + j\frac{f}{f_o}} \]

Graph showing magnitude and phase angle of \( T(f) \) against frequency.
First Order Inverting All Pass Filter
NAME: __________________________________________  SECTION: ____________________________
AD LOGIN: _____________________________________

Experiment 7: First Order Active Filters

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<th>Procedure</th>
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<th>Date Completed</th>
<th>Verification (Must demonstrate circuit)</th>
<th>Points Possible</th>
<th>Points Received</th>
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<td>2. High Pass</td>
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<td>3. High Pass Shelving</td>
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If you were born on or before June 30, your critical frequency is found from your birthday as Month.Day kHz. If you were born after June 30, your critical frequency is (Month.Day/2) kHz. Ex 1: If you were born on March 3, your critical frequency is 3.03 kHz. Ex 2: If you were born on December 18, your critical frequency is 6.09 kHz.

Enter your critical frequency below:

\[ f_{\text{crit}} \]

To be permitted to complete the experiment during the open lab hours, you must complete at least three procedures during your scheduled lab period or spend your entire scheduled lab session attempting to do so. A signature below by your lab instructor, Dr. Brewer, or Dr. Robinson permits you to attend the open lab hours to complete the experiment and receive full credit on the report. Without this signature, you may use the open lab to perform the experiment at a 50% penalty.

SIGNATURE: __________________________________________  DATE: __________________________________________
ECE 3043 Check-off Requirements for Experiment 7

Make sure you have made all required measurements before requesting a check-off. For all check-offs, you must demonstrate the circuit or measurement to a lab instructor. All screen captures must have a time/date stamp.

1 & 2. Low Pass and High Pass Filters
   ✓ Bode magnitude plot
   ✓ Table showing measured pass band gain and -3dB frequencies compared to design values

3 & 4. Low and High Pass Shelving Filters
   ✓ Bode magnitude plot
   ✓ Table showing measured low frequency gain, high frequency gain, and gain at \( f_{crit} \) compared to design values

5. All Pass Filter
   ✓ Bode Phase Plot
   ✓ Measure frequency where phase shift is 90 degrees. Compare to \( f_{crit} \).