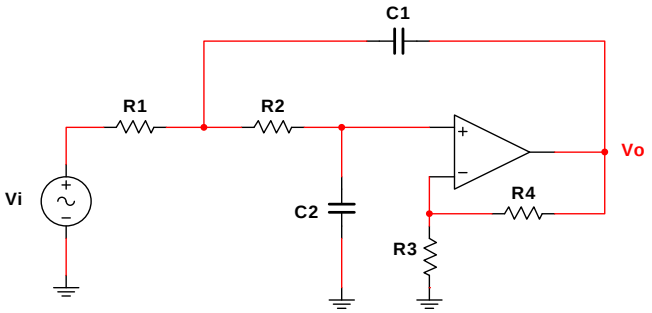
Second Order Low Pass Filter $j := \sqrt{-1}$ $f_{crit} := 10.28\,kHz$ $f_3 := f_{crit}$



$$T(s) = \frac{V_o}{V_i} = K \cdot \frac{1}{\left(\frac{s}{\omega_o}\right)^2 + \frac{1}{Q}\cdot\frac{s}{\omega_o} + 1}$$

$$K = 1 + \frac{R_4}{R_3}$$

K = dc gain

$$Q = \frac{\sqrt{R_1 \cdot R_2 \cdot C_1 \cdot C_2}}{(1-K)\cdot R_1 \cdot C_1 + (R_1 + R_2)\cdot C_2} \qquad \omega_o = 2\pi f_o = \frac{1}{\sqrt{R_1 \cdot R_2 \cdot C_1 \cdot C_2}}$$

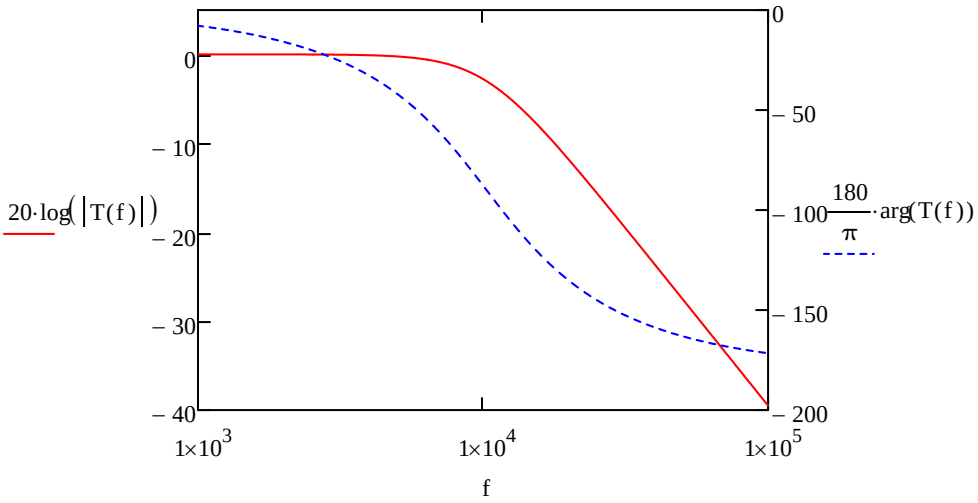
Specifications $Q := \frac{1}{\sqrt{2}}$ Butterworth Filter for which $f_o := f_3$

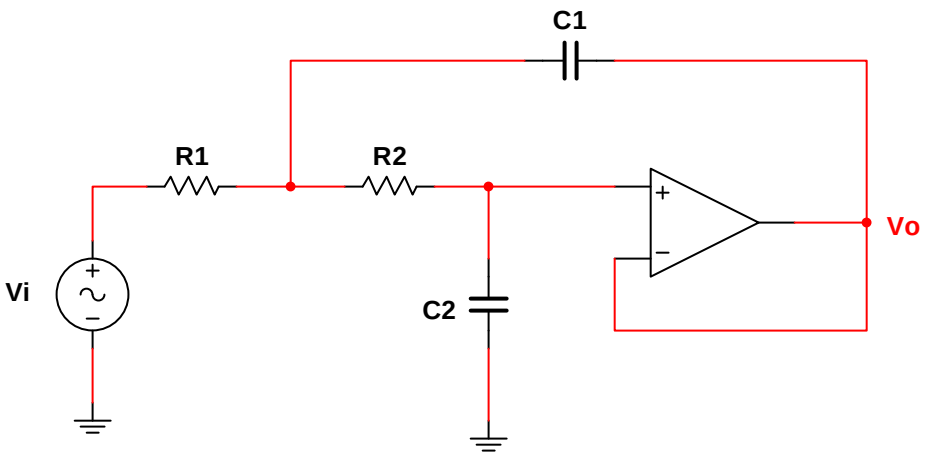
$K := 1$ $R_4 := 0$ short $R_3 := \infty$ open $\omega_o := 2\cdot\pi\cdot f_o$

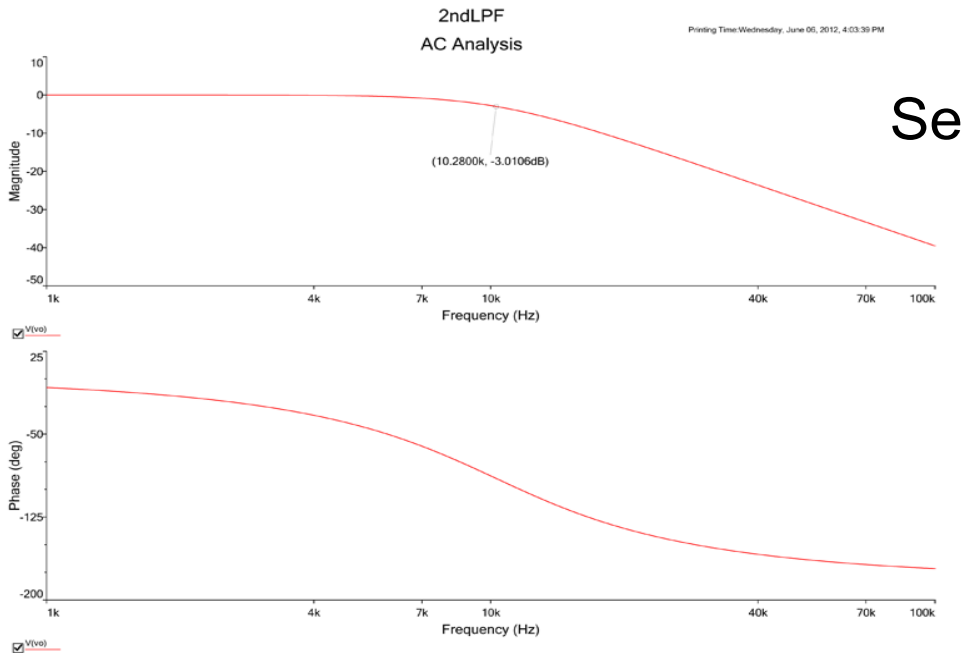
$$T(f) := K \cdot \frac{1}{\left(j\cdot\frac{f}{f_o}\right)^2 + \frac{1}{Q}\cdot j\cdot\frac{f}{f_o} + 1}$$

Special Case 2 Pick $C_1 := 0.015\,\mu F$ $C_2 := 1.5\,nF$

$$R_1 := \frac{1}{2\cdot Q\cdot\omega_o\cdot C_2}\cdot\left(1 + \sqrt{1 - 4\cdot Q^2\cdot\frac{C_2}{C_1}}\right) = 13.826\,k\Omega \qquad R_2 := \frac{1}{2\cdot Q\cdot\omega_o\cdot C_2}\cdot\left(1 - \sqrt{1 - 4\cdot Q^2\cdot\frac{C_2}{C_1}}\right) = 0.771\,k\Omega$$



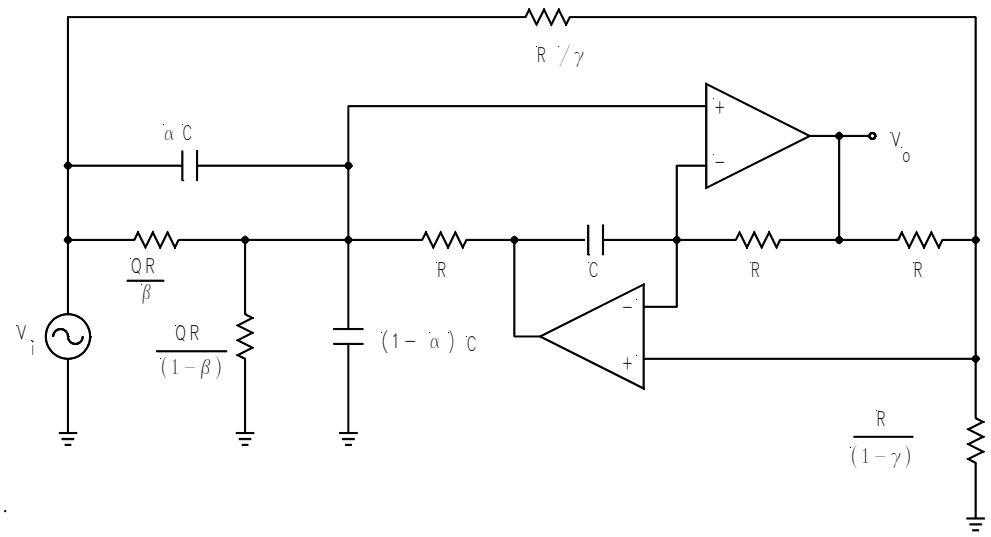




Second Order LPF

Generalized Biquadratic Filter $j := \sqrt{-1}$ page 156 lab manual

$f_{crit} := 10.28\,kHz$ $f_o = \frac{1}{2\pi RC}$ $f_o := f_{crit}$



$$T(s) = \frac{(2\alpha - \gamma)\cdot\left(\frac{s}{\omega_o}\right)^2 + \frac{1}{Q}\cdot\frac{s}{\omega_o}\cdot(2\cdot\beta - \gamma) + \gamma}{\left(\frac{s}{\omega_o}\right)^2 + \frac{1}{Q}\cdot\frac{s}{\omega_o} + 1}$$

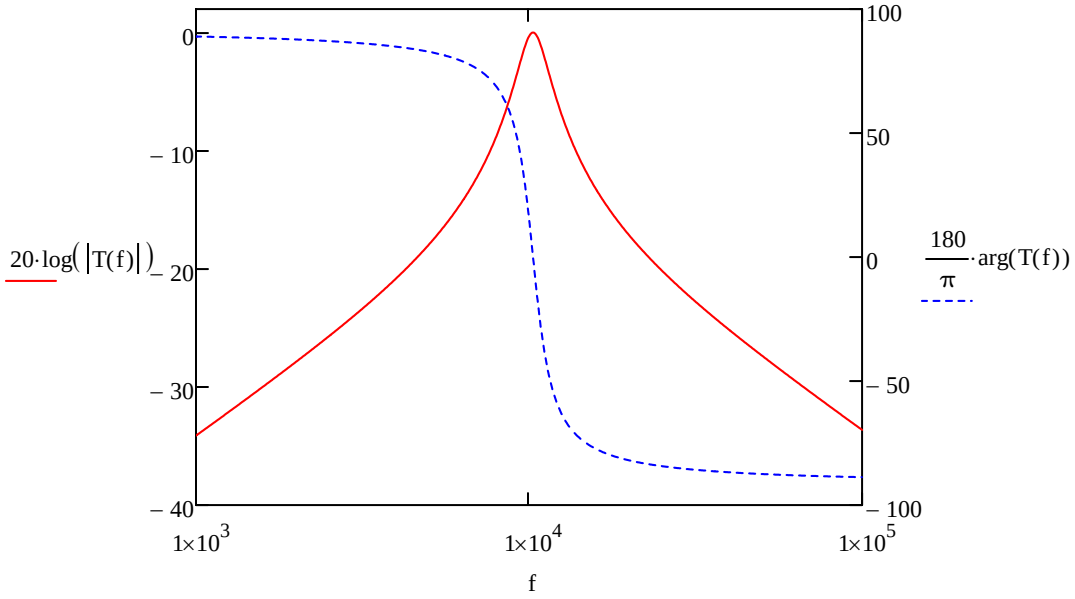
Specification 1 Bandpass

$K := 1$ $Q := 5$ $\alpha = 0$ $\gamma = 0$ $\beta = \frac{1}{2}$

$$T(s) = K\cdot\frac{\frac{1}{Q}\cdot\frac{s}{\omega_o}}{\left(\frac{s}{\omega_o}\right)^2 + \frac{1}{Q}\cdot\frac{s}{\omega_o} + 1}$$

$$T(f) := K\cdot\frac{j\cdot\frac{f}{f_o}\cdot\frac{1}{Q}}{\left(j\cdot\frac{f}{f_o}\right)^2 + \frac{1}{Q}\cdot j\cdot\frac{f}{f_o} + 1}$$

Second Order Bandpass Filter

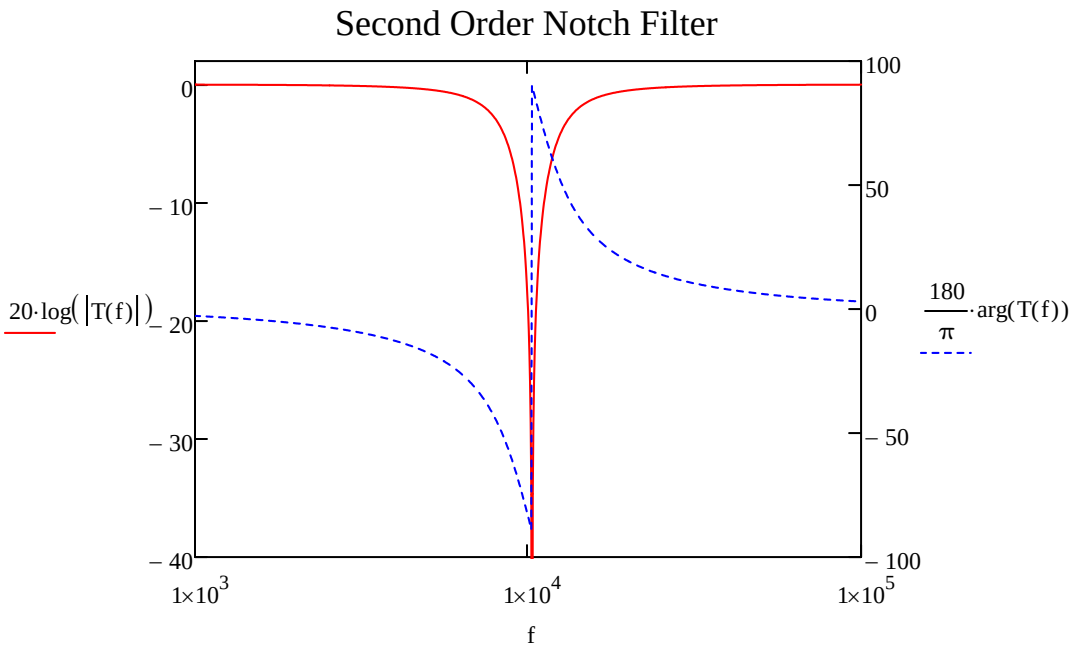


Specification 2 Second Order Notch Filter DC and High Freq Gain 1 Q of 2

$\alpha = \gamma = 1$ $\beta = \frac{1}{2}$ $Q := 2$

$$T(s) = K \cdot \frac{\left(\frac{s}{\omega_o}\right)^2 + 1}{\left(\frac{s}{\omega_o}\right)^2 + \frac{1}{Q} \cdot \frac{s}{\omega_o} + 1}$$

$$T(f) := K \cdot \frac{\left(j \cdot \frac{f}{f_o}\right)^2 + 1}{\left(j \cdot \frac{f}{f_o}\right)^2 + \frac{1}{Q} \cdot j \cdot \frac{f}{f_o} + 1}$$



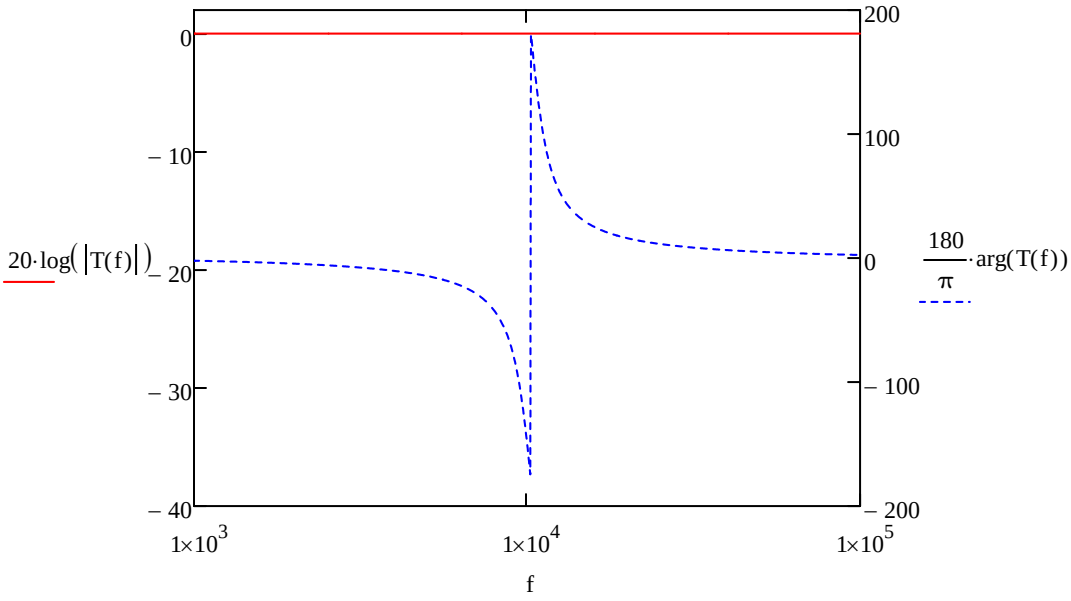
Specification 3 Second Order All Pass

$\alpha = 1$ $\beta = 0$ $\gamma = 1$ $K := 1$ $Q := 5$

$$T(s) = K\cdot\frac{\left(\frac{s}{\omega_o}\right)^2 - \frac{1}{Q}\cdot\frac{s}{\omega_o} + 1}{\left(\frac{s}{\omega_o}\right)^2 + \frac{1}{Q}\cdot\frac{s}{\omega_o} + 1}$$

$$T(f) := K\cdot\frac{\left(j\cdot\frac{f}{f_o}\right)^2 - \frac{1}{Q}\cdot j\cdot\frac{f}{f_o} + 1}{\left(j\cdot\frac{f}{f_o}\right)^2 + \frac{1}{Q}\cdot j\cdot\frac{f}{f_o} + 1}$$

Second Order AllPass Filter



Georgia Institute of Technology

School of Electrical and Computer Engineering

ECE 3043 Electrical and Electronic Circuits Laboratory Verification Sheet

NAME:_____ SECTION:_____

AD LOGIN:_____

Experiment 8: Second Order Active Filters

Procedure	Time Completed	Date Completed	Verification (Must demonstrate circuit)	Points Possible	Points Received
1. Low Pass				20	
2. High Pass				20	
3. Bandpass				20	
4. Notch				20	
5. All-Pass				20	

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_{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 8

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. Bandpass and Notch Filters

- ✓ Bode magnitude plot
- ✓ Table showing measured center frequency and half power bandwidth

5. All Pass Filter

- ✓ Bode Phase Plot
- ✓ Measure frequency where phase shift is 180 degrees. Compare to f_{crit}.