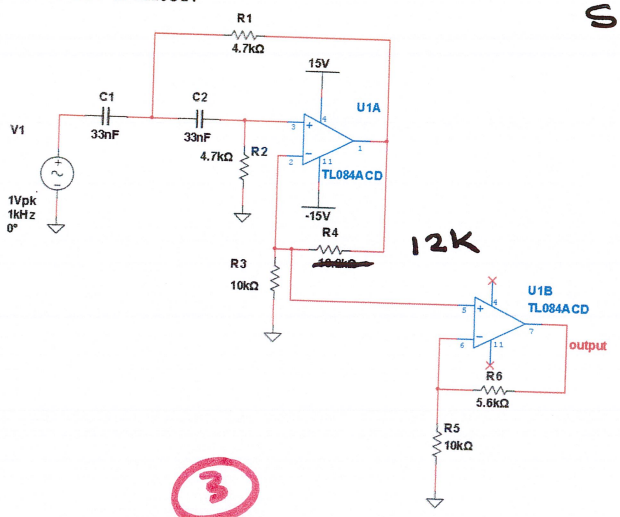
ECET 337
Exam 3
Spring 2025A

Solutions
Name

Filter type	Damping (α)	Correction (K_{lp})
Bessel	1.732	0.785
Butterworth	1.414	1.000
3 dB Chebyshev	0.766	1.390

1. Below is the schematic for a filter.

5K HP



a. [10%] Write the transfer function in terms of A_o, ω_o, α, and s.

$$\frac{V_{out}(s)}{E_{in}(s)} = \frac{A_o s^2}{s^2 + \alpha \omega_o s + \omega_o^2}$$

b. [9%] Calculate the numerical value of each of these parameters

$A_o = \dfrac{1.56}{1 + \frac{5.6k\Omega}{10k}}$ $\omega_o = \dfrac{6.45k\ rad/s}{\frac{1}{4.7k\Omega * 33nF}}$ $\alpha = 0.80$ $3 - A_{INT} = 3 - \left(1 + \frac{12}{10k}\right)$

c. [16%] Calculate the following parameters.

1) $V_{out\ RMS\ @\ 20\ kHz}$ = 1.56V → 1.1V 1V * 1.56 * 0.707

2) (circle one) low-pass band-pass high-pass

3) (circle one) Bessel Butterworth Chebyshev

4) f_o = 1.03k Hz $f_o = \frac{1}{2\pi * 4.7k * 33nF}$

5) What happens at f_o? phase shifted +90°

6) f_{-3dB} = 741 Hz = $k_{HP} * f_o = \frac{1}{1.39} * 1.03kHz$

7) What happens at f_{-3dB}? gain dropped by 0.707

8) Roll-off rate = + 12 dB/oct
or +40 dB/decade

2. Below are the parameters for a filter.

1) f_{3dB} = 2k Hz
2) low pass
3) $E_{in\,DC}$ = 1 V_{DC} $V_{out\,DC}$ = 1 V_{DC}
4) Butterworth
5) order = 2nd

a. [10%] Write the transfer function in terms of A_o, ω_o, α, and s.

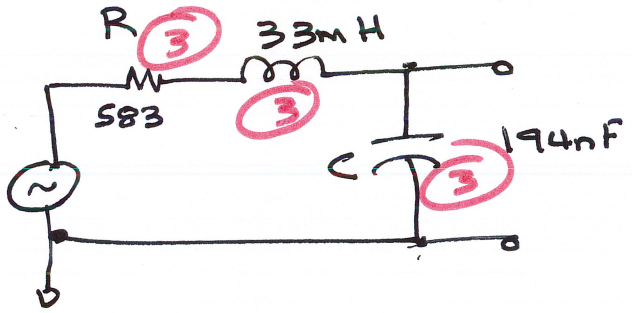
$$\frac{V_{out}(s)}{E_{in}(s)} = \frac{A_o \omega_o^2}{s^2 + \alpha \omega_o s + \omega_o^2}$$

b. [9%] Calculate the numerical value of each of these parameters

A_o = 1 ω_o = 12.57 k rad/sec α = 1.414

$\omega_o = 2\pi f_o = 2\pi * 2kHz$

b. [16%] Draw the schematic below using only an inductor, capacitor and resistor. Choose L = 33 mH. Show *all* of the calculations for the value of each component that you add.



$$\omega_o = \frac{1}{\sqrt{LC}} \qquad \omega_o^2 = \frac{1}{LC}$$

$$C = \frac{1}{\omega_o^2 L} = \frac{1}{(12.57k)^2 * 33mH} = 194\ nF$$

$$\zeta = \frac{1}{2} R \sqrt{\frac{C}{L}} \qquad 2\zeta \sqrt{\frac{L}{C}} = R$$

$$R = 2 * 0.707 \sqrt{\frac{33mH}{194nF}} = 583\ \Omega$$

3. Below is the transfer function for a filter.

$$\frac{V_{out\,(s)}}{E_{in\,(s)}} = \frac{-1200\,s}{s^2 + 600\,s + 40 \times 10^3}$$

a. [10%] Write the transfer function in terms of A_o, ω_o, α, and s.

$$\frac{V_{out\,(s)}}{E_{in\,(s)}} = \frac{A_o \alpha \omega_o s}{s^2 + \alpha \omega_o s + \omega_o^2}$$

(4) (1) (3) (2)

[14%] Calculate the following parameters.

1) *Type* low-pass (band-pass) high-pass (circle one)

2) ω_o = 200 rad/sec $\sqrt{40 \times 10^3}$

3) f_o = 31.8 Hz $\omega_o = 2\pi f_o$ $f_o = \frac{200}{2\pi}$ rad/sec

200

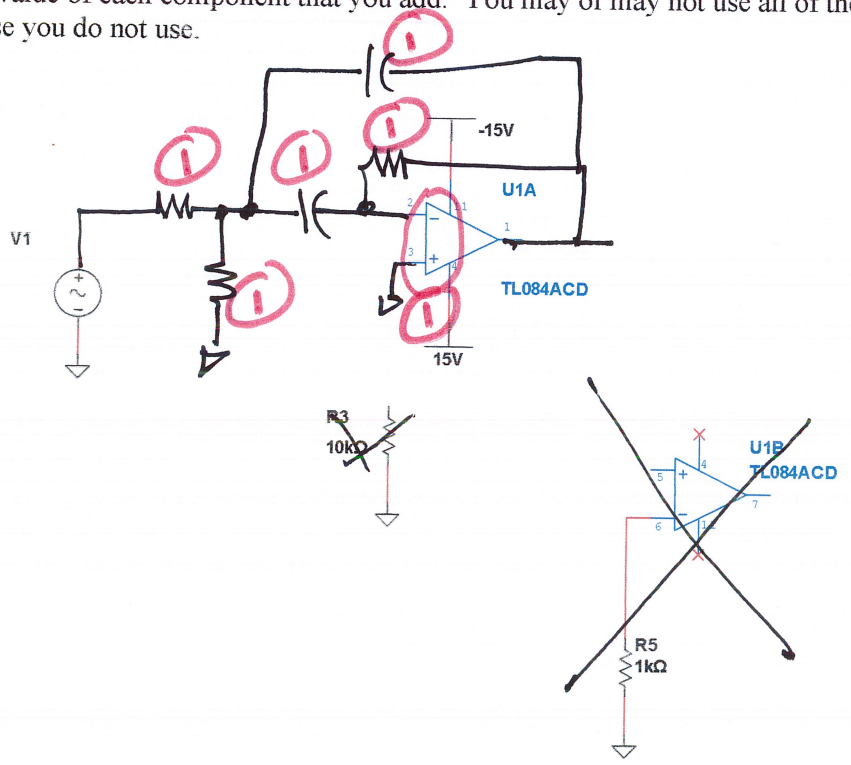
4) *phase at* f_o = ± 180° 0° ⇒ -1

5) α = 3 $\alpha \omega_o = 600$ $\alpha = 600/200$

6) A_o = −2 $A_o \alpha \omega_o = -1200$ $A_o = \frac{-1200}{3 \times 200}$

7) Roll-off rate between 1 kHz and 2 kHz = − 6 dB/oct −12dB ⇒ -1

b. [6%] Complete the schematic below. ~~Choose C = 100 nF. Show *all* of the calculations for the value of each component that you add.~~ You may or may not use all of the parts. X out those you do not use.



ECET 337
Exam 3
Spring 2025B

Solutions

Name

Filter type	Damping (α)	Correction (k_{lp})
Bessel	1.732	0.785
Butterworth	1.414	1.000
3 dB Chebyshev	0.766	1.390

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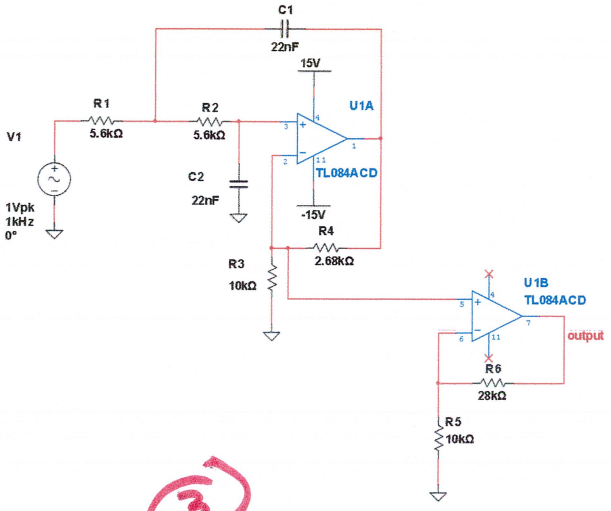
1. Below is the schematic for a filter.



a. [10%] Write the transfer function in terms of A_o, ω_o, α, and s.

$$\frac{V_{out}(s)}{E_{in}(s)} = \frac{A_o \omega_o^2}{s^2 + \alpha \omega_o s + \omega_o^2}$$

$A_{INT} = 1 + \frac{2.68k}{10k} = 1.268$

$\alpha = 3 - 1.268$

b. [9%] Calculate the numerical value of each of these parameters

$A_o =$ 3.8 $\quad$ $1 + \frac{28k}{10k}$

$\omega_o =$ 8.12k rad/sec $\quad$ $\frac{1}{5.6k\Omega * 22nF}$

$\alpha =$ 1.73

c. [16%] Calculate the following parameters.

1) $V_{out\,@\,DC} =$ 3.8 V_{DC} = $A_o * 1V_{DC}$

2) (circle one) (low-pass) band-pass high-pass

3) (circle one) (Bessel) Butterworth Chebyshev

4) $f_o =$ 1.29kHz $\quad \omega_o = 2\pi f_o \quad f_o = \omega_o / 2\pi$

5) What happens at f_o? phase shifted −90°

6) $f_{-3dB} =$ 1kHz $\quad = k_{LP} * f_o = 0.785 * 1.28kHz$

7) What happens at f_{-3dB}? Gain drops −3dB below A_{oDB} (0.707 * A_o)

8) Roll-off rate = − 12dB/oct

or

−40 dB/decade

2. Below are the parameters for a filter.

1) $f_{-3dB} = 440$ Hz
2) high pass
3) $E_{in} = 1\ V_{RMS}$ $V_{out\ @\ 50kHz} = 1\ V_{RMS}$
4) Butterworth
5) order = 2^{nd}

a. [10%] Write the transfer function in terms of A_o, ω_o, α, and s.

$$\frac{V_{out}(s)}{E_{in}(s)} = \frac{A_o s^2}{s^2 + \alpha\omega_o s + \omega_o^2}$$

b. [9%] Calculate the numerical value of each of these parameters

$A_o = 1$ $\omega_o = 2.7\text{k}$ rad/sec $\alpha = 1.414$

b. [16%] Draw the schematic below using only an inductor, capacitor and resistor. Choose L = 33 mH. Show *all* of the calculations for the value of each component that you add.

$f_o = f_{-3dB}$ (Butterworth)

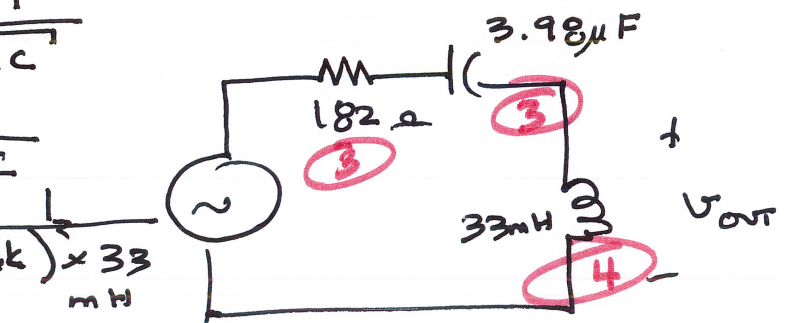
$\omega_o = 2\pi f_o = 2\pi * 440\text{Hz}$

$\omega_o = \frac{1}{\sqrt{LC}}$

$\omega_o^2 = \frac{1}{LC}$

$C = \frac{1}{(2.7\text{k})^2 \times 33\text{ mH}}$

$C = 3.98\ \mu F$



$\zeta = \frac{1}{2} R \sqrt{\frac{C}{L}}$

$R = 2\zeta \sqrt{\frac{L}{C}}$

$R = 2 * 0.707 * \sqrt{\frac{33\text{mH}}{3.98\mu F}}$

$R = 128\ \Omega$

3. Below is the transfer function for a filter.

$$\frac{V_{out}(s)}{E_{in}(s)} = \frac{-700\,s}{s^2 + 130\,s + 160 \times 10^3}$$

a. [10%] Write the transfer function in terms of A_o, ω_o, α, and s.

$$\frac{V_{out}(s)}{E_{in}(s)} = \frac{A_o \alpha \omega_o s}{s^2 + \alpha \omega_o s + \omega_o^2}$$

(1) (2) (3) (4)

[14%] Calculate the following parameters.

1) *Type* low-pass **band-pass** high-pass (circle one)

2) ω_o = 400 rad/sec $\sqrt{160 \times 10^3}$

3) f_o = 64 Hz $\omega_o = 2\pi f_o$ $f_o = 400/2\pi =$

4) *phase at* f_o = $\pm$ 180°

5) α = 0.325 $\alpha \omega_o = 130$ $\alpha = 130/400 = 0.325$

6) A_o = 5.38 $A_o \alpha \omega_o = -700$ $A_o = \frac{-700}{130}$

7) Roll-off rate between 20 Hz and 40 Hz = + 6 dB / oct

b. [6%] Complete the schematic below. Calculate *no* component values. You may or may not use all of the parts. X out those you do not use.