# ECE 214 — Final Exam

Estimated time for completion: $\lesssim$ 2 hour
10 May 2018

Rules of the Exam

**Rule 1:** The examination period begins at 10:30 am on Thursday, 10 May 2018, and ends at 12:30 pm on Thursday, 10 May 2018.

**Rule 2:** The exam is worth 20 points.

**Rule 3:** There are three problems each worth seven points, plus one optional extra credit problem worth three points.

**Rule 4:** The exam is closed book and closed notes. You may use your ECE 214 Laboratory Notebook, a ruler, and a calculator.

**Rule 5:** To receive credit for an answer include the units along with the numerical answer.

**Rule 6:** Show all work - answers without supporting work will not receive credit.

**Rule 7:** Do not leave the room until you have completed the exam.

Spencer Goulette
Name

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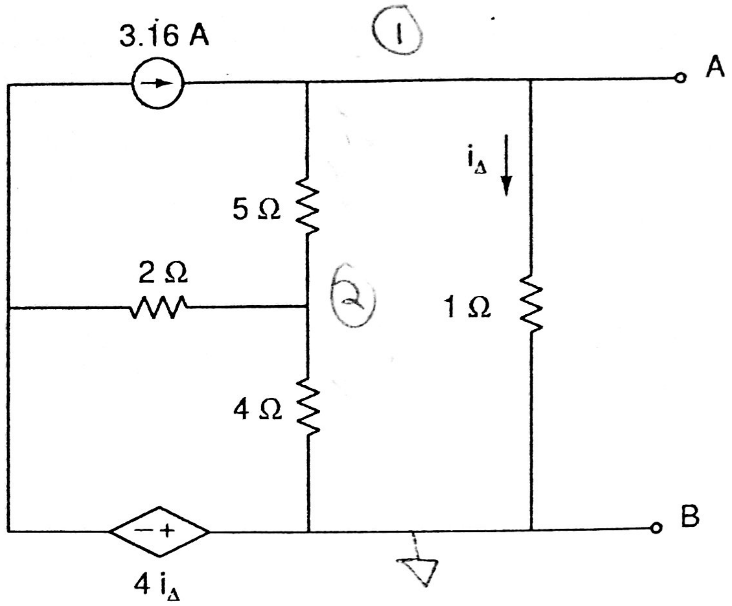
**Problem 1:** Consider the circuit below:




Draw the Thèvenin Equivalent Circuit with respect to terminals A and B.

$\frac{3}{7}$

KCL @ 1

$$\frac{V_1}{1} - 3.16 + \frac{V_1 - V_2}{5} = 0$$

KCL @ 2

$$\frac{V_2 - V_1}{5} + 3.16 + 4V_1 + \frac{V_2}{4} = 0$$

$$-4V_1 + 4V_2 + 63.2 + 80V_1 + 5V_2 = 0$$

$$9V_2 + 76V_1 + 63.2 = 0$$

$$V_2 = -8.44V_1 - 7.022$$

$$V_1 - 3.16 + \frac{V_1 + 8.44V_1 + 7.022}{5} = 0$$

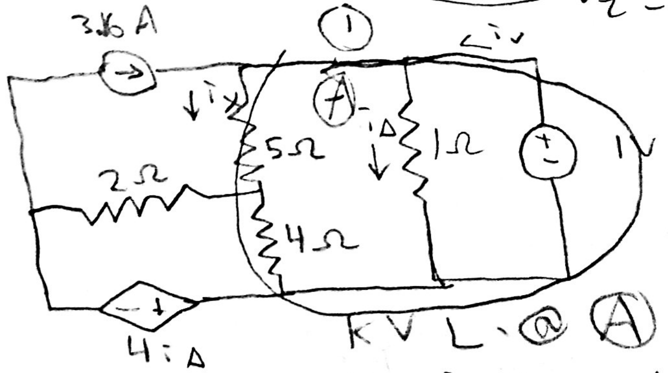
$$5V_1 - 15.8 + 9.44V_1 + 7.022 = 0$$

$$V_1 = 0.608\text{ V}$$

$$V_2 = -12.2\text{ V}$$

$$\boxed{V_{TH} = 0.608\text{ V}}$$

?




Ohm's Law

$$\frac{1\text{V}}{1\Omega} = i_\Delta$$

$$i_\Delta = 1\text{ A}$$

KVL @ A

$$1\text{V} = i_x 5\Omega + (i_x - 3.16 - 4)4$$

$$1\text{V} = 5i_x + 4i_x - 28.64$$

$$29.64 = 9i_x$$

$$i_x = 3.29\text{A}$$

KCL @ 1

$$i_x + i_\Delta - i_v - 3.16 = 0$$

$$3.29 + 1 - i_v - 3.16 = 0$$

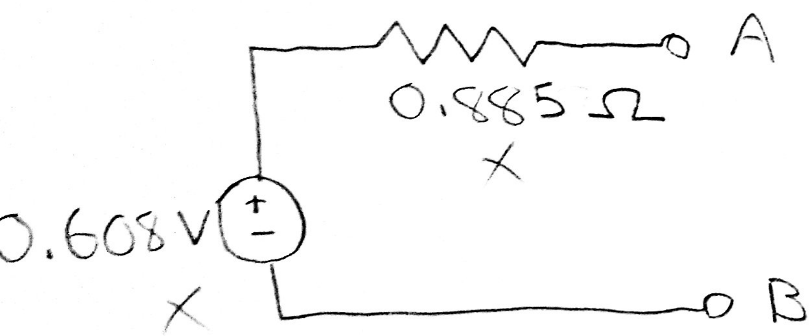
$$i_v = 1.13$$



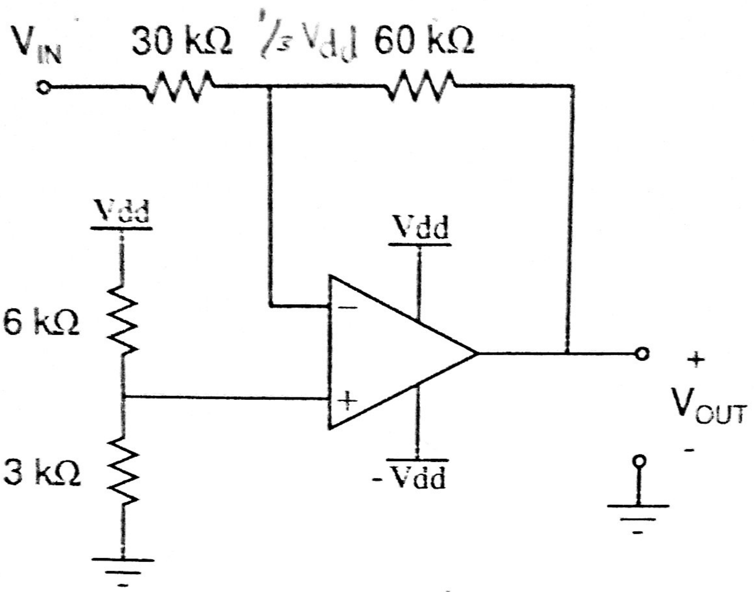
$$\boxed{R_{TH} = \frac{1\text{V}}{1.13} = 0.885\Omega}$$

DRAWING ON NEXT PAGE

Thévenin Equivalent Circuit



Assume the OpAmp is ideal with $V_{dd} = 9$ V.

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$\frac{1}{3}$ Vdd

1. What is the function of this circuit?

(a) inverting amplifier with DC offset

(b) non-inverting amplifier with DC offset

(c) comparator

(d) Schmitt trigger

(e) inverting integrator

(f) inverting integrator with DC offset

$\frac{1/3\ Vdd}{30K} \cdot 90K$

Vdd

2. $V_{IN}$ is a triangular waveform with 1 V peak-to-peak voltage and 4.5 V DC offset. What type of waveform is $V_{OUT}$?

(a) sinusoidal waveform

(b) triangular waveform

(c) triangular waveform with a DC offset

(d) square waveform

(e) square waveform with a DC offset

(f) DC output equal to 0 V

$\frac{\frac{1}{3} Vdd + 3}{30k} \cdot 90K$

Vdd + 9V

3. $V_{IN} = 0$ V. What is $V_{OUT}$? 9V

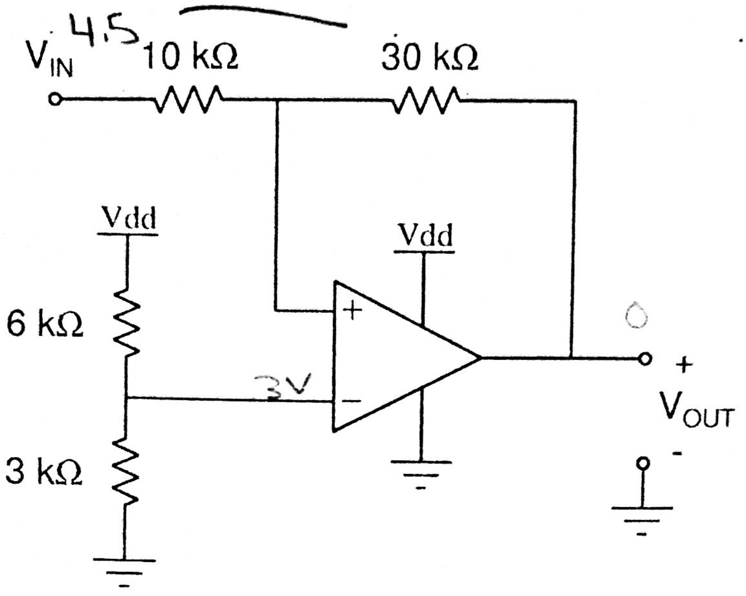
4. $V_{IN} = -3$ V. What is $V_{OUT}$? 18V

5. $V_{IN} = 3$ V. What is $V_{OUT}$? 0V

$\frac{\frac{1}{3} Vdd - 3}{30k} \cdot 90k$

Vdd - 9V

Assume the OpAmp is ideal with $V_{dd} = 9$ V.




6. What is the function of this circuit?

   (a) inverting amplifier with DC offset

   (b) non-inverting amplifier with DC offset

   (c) comparator

   (d) Schmitt trigger

   (e) inverting integrator

   (f) inverting integrator with DC offset

$\frac{1}{3}$ Vdd

7. $V_{IN}$ is a triangular waveform with 1 V peak to peak voltage and 0 V DC offset. What type of waveform is $V_{OUT}$?

   (a) sinusoidal waveform

   (b) triangular waveform

   (c) triangular waveform with a DC offset

   (d) square waveform

   (e) square waveform with a DC offset

   (f) DC output equal to 0 V

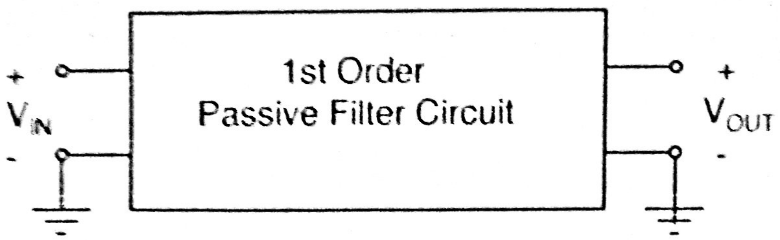
in order to be square waveform, input needs to be atleast 4V

8. When $V_{IN} = 0$ V, what is $V_{OUT}$? 0 V

9. When $V_{IN} = 4.5$ V, what is $V_{OUT}$? Vdd

10. When $V_{IN} = 9$ V, what is $V_{OUT}$? Vdd

**Problem 3:** Consider the 1st order ideal passive filter circuit shown below:

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For the questions below circle the <u>most correct</u> answer:

1. $V_{IN}$ is a sine wave with a frequency of 150 kHz and a peak-to-peak voltage of 5 V. $V_{OUT}$ is a sinusoidal waveform with a frequency of 150 kHz and a peak-to-peak voltage of 2 V. What type of filter could be used to generate $V_{OUT}$?

   (a) low pass filter

   (b) high pass filter

   (c) band reject filter

   (d) all of the above

   (e) none of the above

2. $V_{IN}$ is a square wave with a 50% duty cycle, a frequency of 50 kHz, and a peak-to-peak voltage of 5 V. $V_{OUT}$ that is a sinusoidal waveform with a frequency of 200 kHz and peak-to-peak voltage of 1 V? What type of filter could be used to generate $V_{OUT}$?

   (a) low pass filter

   (b) band pass filter

   (c) band reject filter

   (d) high pass filter

   (e) none of the above

3. $V_{IN}$ is a square wave with a 50% duty cycle, a frequency of 50 kHz, and a peak-to-peak voltage of 10 V. The filter is a low pass filter with a cutoff frequency of 100 kHz. What is the relative amplitude of the 7th harmonic to the fundamental at the output of the filter?

(a) -3.0 dB
(b) -8.0 dB
(c) -10.9 dB
(d) -13.9 dB
(e) -16.9 dB
(f) -19.9 dB
(g) -22.8 dB
(h) -26.0 dB
(i) -33.9 dB
(j) none of the above

$f_{fund}$ : 0 filter: 0

$f_{7th}$ : $20\log(\frac{1}{7})$ filter: $-20\log(\frac{350k}{100k})$

relative amplitude: $20\log(\frac{1}{7}) + -20\log(\frac{350k}{100k}) = -27.8$ dB

4. $V_{IN}$ is a square wave with a 50% duty cycle, a frequency of 50 kHz, and a peak-to-peak voltage of 10 V. The filter is a low pass filter with a cutoff frequency of 50 kHz. What is the relative amplitude of the 7th harmonic to the fundamental at the output of the filter?

(a) -3.0 dB
(b) -8.0 dB
(c) -10.9 dB
(d) -13.9 dB
(e) -16.9 dB
(f) -19.9 dB
(g) -22.8 dB
(h) -26.0 dB
(i) -33.9 dB

$f_{fund}$ : 0 filter: -3

$f_{7th}$ : $20\log(\frac{1}{7})$ filter: $-20\log(\frac{350k}{50k})$

different

relative amplitude $= 20\log(\frac{1}{7}) - 20\log(\frac{350k}{50k}) + 3 = -30.8$ dB

... pretty sure it is -30.8 dB

5. $V_{IN}$ is a square wave with a 50% duty cycle, a frequency of 50 kHz, and a peak-to-peak voltage of 10 V. The filter is a high pass filter with a cutoff frequency of 50 kHz. What is the peak amplitude of the 7th harmonic at the output of the filter?

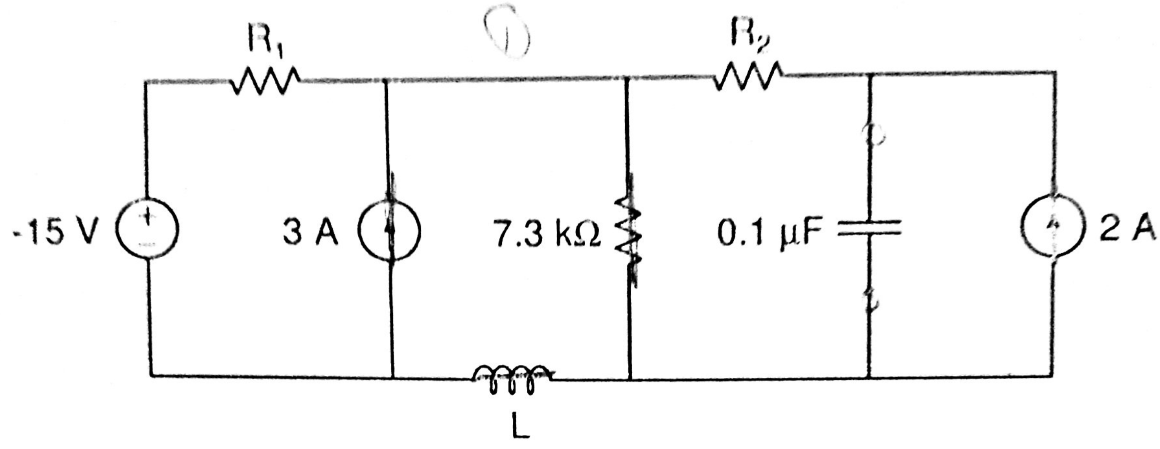
(a) -3.0 dB
(b) -8.0 dB
(c) -10.9 dB
(d) -13.9 dB
(e) -16.9 dB
(f) -19.9 dB
(g) -22.8 dB
(h) -26.0 dB
(i) -33.9 dB

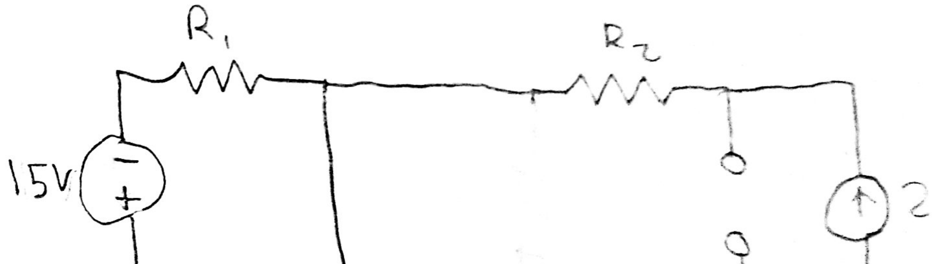
$f_{fund}$ : 0 filter: -3

$f_{7th}$ : $20\log(\frac{1}{7})$ filter: 0

peak amplitude $= 20\log(\frac{1}{7}) = -16.9$ dB

**Optional Bonus Problem:** In the circuit below, the 3 A source delivers no power and absorbs no power. The circuit dissipates a total of 155 W of power and stores 0.1 mJ of energy.




What are:

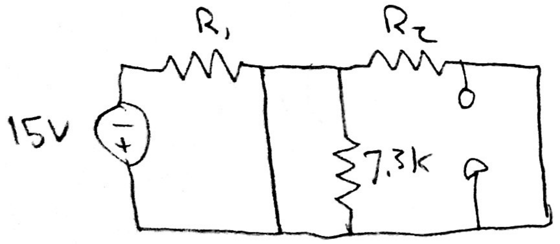
$R_1 =$ 1.45 Ω ✗

$R_2 =$ 0 Ω ✗

$L =$ 50 μH ✓

$P_{diss} = \frac{15^2}{R_1} + \cancel{2^2 R_2}$

$155 = \frac{225}{R_1} + \cancel{4R_2} \Rightarrow R_1 = 1.45\ \Omega$




~~Just picking a value for $R_1$~~

$\cancel{R_1 = 3\ \Omega}$

$\cancel{155 = \frac{225}{3} + 4R_2}$

$\cancel{R_2 = 20}$

$\frac{15^2}{R_1}$

3A

KCL @ 1

$-3A + \frac{V_1}{7.3k} + \frac{V_1 + 15}{R_1} = 0$

$V_1$

$\cancel{20 \cdot 2 = 40\ V}$

~~40 V~~ across capacitor

$0.1 \cdot 10^{-3} = \cancel{\frac{1}{2} C V^2} + \frac{1}{2} L i^2$

$0.1 \cdot 10^{-3} = \cancel{\frac{1}{2} \cdot 0.1\mu \cdot 40^2} + \frac{1}{2} \cdot L \cdot 2^2$