ECE 214 — Make up Exam #1

Estimated time for completion: $\leq$ 1.25 hour
22 March 2017

Rules of the Exam

Rule 1: The examination period begins at 5:00pm on Wednesday 22 March 2017 and ends at 6:15am on Wednesday 22 March 2017.

Rule 2: The exam is 15% of your grade.

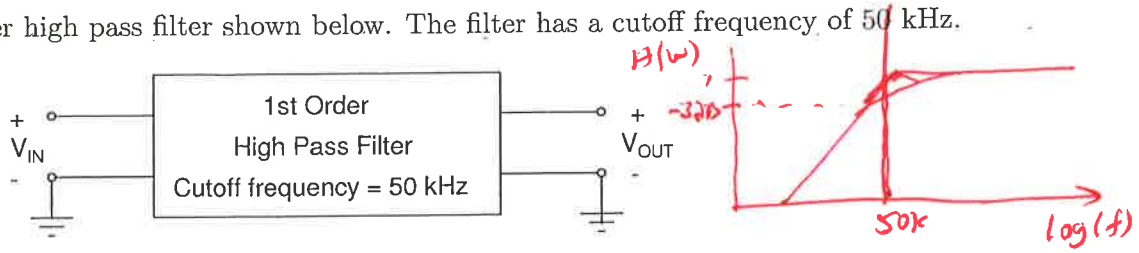
Rule 3: There are a total of 15 answers. Each answer is worth 1 point. Circle the most correct answer.

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

Answer Key
Name

Problem 1: 1st Order High Pass Filter

Consider the first order high pass filter shown below. The filter has a cutoff frequency of 50 kHz.



1. V_{IN} is a triangular wave with a 50% duty cycle and a frequency of 100 kHz. What is the relative amplitude of the 5th harmonic to the fundamental frequency at the output of the filter?

   (a) 0 dB
   (b) -3 dB
   (c) -11 dB
   (d) -14 dB
   (e) -17 dB
   (f) -21 dB
   (g) -28 dB
   (h) none of the above

   $20\log(\frac{1}{15})$

   100KHz is in the passband

2. V_{IN} is a square wave with a 50% duty cycle and a frequency of 100 kHz. What is the relative amplitude of the 5th harmonic to the fundamental frequency at the output of the filter?

   (a) 0 dB
   (b) -3 dB
   (c) -11 dB
   (d) -14 dB
   (e) -17 dB
   (f) -21 dB
   (g) -28 dB
   (h) none of the above

   $20\log(\frac{1}{5})$

   100 KHz is in the passband

3. V_{IN} is a square wave with a 50% duty cycle and a frequency of 50 kHz. What is the relative amplitude of the 5th harmonic to the fundamental frequency at the output of the filter?

   (a) 0 dB
   (b) -3 dB
   (c) -11 dB
   (d) -14 dB
   (e) -17 dB
   (f) -21 dB
   (g) -28 dB
   (h) none of the above

   $-14 + 3$ dB

   Fundamental attenuated by 3 dB

4. V_{IN} is a square wave with a 50% duty cycle and a frequency of 10 kHz. What is the relative amplitude of the 5th harmonic to the fundamental frequency at the output of the filter?

(a) 0 dB
(b) -3 dB
(c) -11 dB
(d) -14 dB
(e) -17 dB
(f) -21 dB
(g) -28 dB
(h) none of the above

Fundamental: $\frac{-20\,dB}{decade} \times \frac{\log(5)}{\log(10)} = -14\,dB$

5th harmonic: $-3\,dB$

Fundamental: $0 - 14 = -14$
5th harmonic: $-14 - 3 = -18$
$\Delta = -3\,dB$

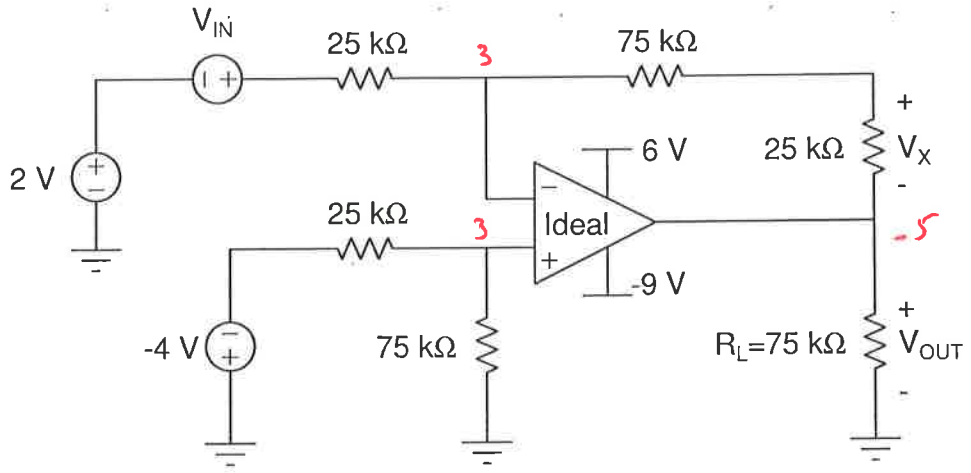
5. V_{IN} is a square wave with a 50% duty cycle and a frequency of 1 kHz. What is the relative amplitude of the 3rd harmonic to the fundamental frequency at the output of the filter?

(a) 0 dB
(b) -3 dB
(c) -11 dB
(d) -14 dB
(e) -17 dB
(f) -21 dB
(g) -28 dB
(h) none of the above

Fundamental attenuated by -9.54 dB by filter and is at the same voltage level as 3rd harmonic

difference between fundamental & 3rd harmonic = 0 dB

Problem 2: Consider the OpAmp circuit below. The OpAmp is ideal.



1. When $V_{IN} = 0$ V what is the value of V_{OUT}?

   (a) -9 V
   (b) -5 V
   (c) -2 V
   (d) 0 V
   (e) +2 V
   (f) +6 V ← Saturated
   (g) None of the above

$\frac{V_{in}+2-3}{25} = \frac{3-V_{out}}{100}$

$4(V_{in}-1) = 3-V_{out}$

$V_{out} = 7-4V_{in}$

2. When $V_{IN} = +8$ V what is the value of V_{OUT}?

   (a) -9 V ← Saturated
   (b) -5 V
   (c) -2 V
   (d) 0 V
   (e) +2 V
   (f) +6 V
   (g) None of the above

3. When $V_{IN} = +3$ V what is the value of V_{OUT}?

(a) -9 V
(b) -5 V
(c) -2 V
(d) 0 V
(e) +2 V
(f) +6 V
(g) None of the above

$V_{out} = 7 - 4V_{in}$

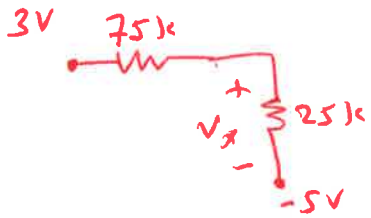
4. If $V_{IN} = +3$ V and the resistance R_L is increased by 10X, how does V_{OUT} change?

(a) V_{OUT} increases by 2.5X
(b) V_{OUT} increases by more than 2.5X
(c) V_{OUT} decreases by 2.5X
(d) V_{OUT} decreases by more than 2.5X
(e) V_{OUT} stays the same
(f) None of the above

V_{out} does not depend on R_L

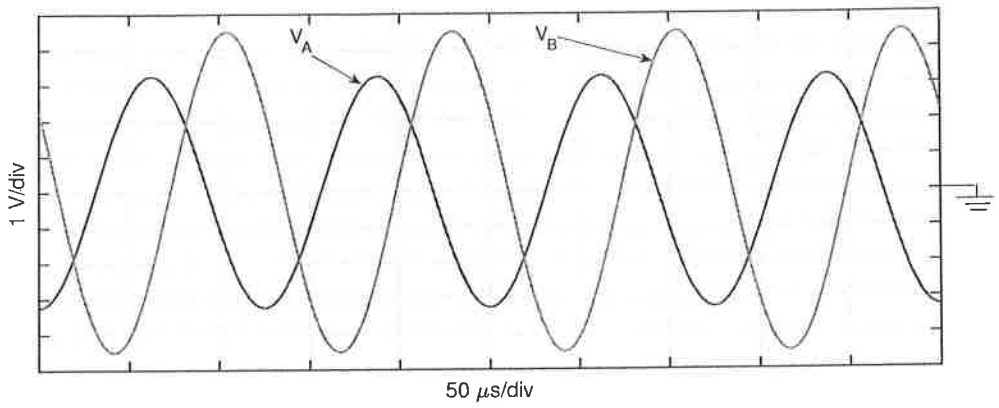
5. When $V_{IN} = +3$ V what is the value of V_X?

(a) -9 V
(b) -5 V
(c) -2 V
(d) 0 V
(e) +2 V
(f) +6 V
(g) None of the above



$V_x = \frac{1}{4} \times 8 = 2V$

Problem 3: Consider the oscilloscope trace shown below. Signal V_A is the input to an amplifier and V_B is the output from an amplifier.



The two sinusoidal signals can be represented by:

$$V_A(t) = A\cos(\omega t + \phi_1)V$$

and

$$V_B(t) = B\cos(\omega t + \phi_2)V$$

1. What is the gain of the amplifier?
   (a) 1.4
   (b) 2.8
   (c) 4.2
   (d) 5.6
   (e) None of the above
2. What is ω?
   (a) 2k rad/s
   (b) 4k rad/s
   (c) 8k rad/s
   (d) 25k rad/s
   (e) 50k rad/s
   (f) none of the above

3. Which of the following statements best describes the phase shift between V_A and V_B?

   (a) V_A leads V_B by 60°
   (b) V_A lags V_B by 60°
   (c) V_A leads V_B by 120°
   (d) V_A lags V_B by 120°
   (e) V_A lags V_B on the positive cycle and V_A leads V_B on the negative cycle

4. What is A?

   (a) 2.3 V
   (b) 3.2 V
   (c) 4.5 V
   (d) 6.4 V
   (e) 9.0 V

5. If the voltage A is measured on a DVM set to measure an AC voltage, what value would it read?

   (a) 2.3 V
   (b) 3.2 V
   (c) 4.5 V
   (d) 6.4 V
   (e) 9.0 V

$\frac{3.2}{\sqrt{2}}$