

**ENGR-4300**

**Fall 2008**

**Test 4**

Name \_\_\_\_\_ **SOLUTION** \_\_\_\_\_

Section 1(MR 8:00) 2(TF 2:00)  
(circle one)

Question I (20 points) \_\_\_\_\_

Question II (20 points) \_\_\_\_\_

Question III (15 points) \_\_\_\_\_

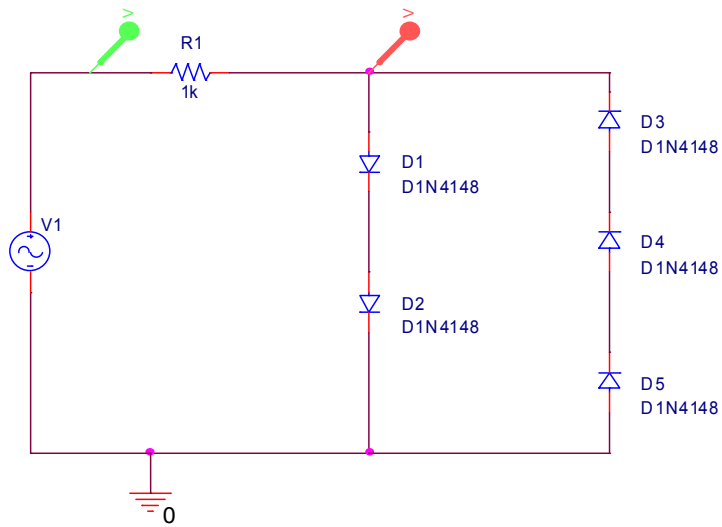
Question IV (20 points) \_\_\_\_\_

Question V (25 points) \_\_\_\_\_

Total (100 points): \_\_\_\_\_

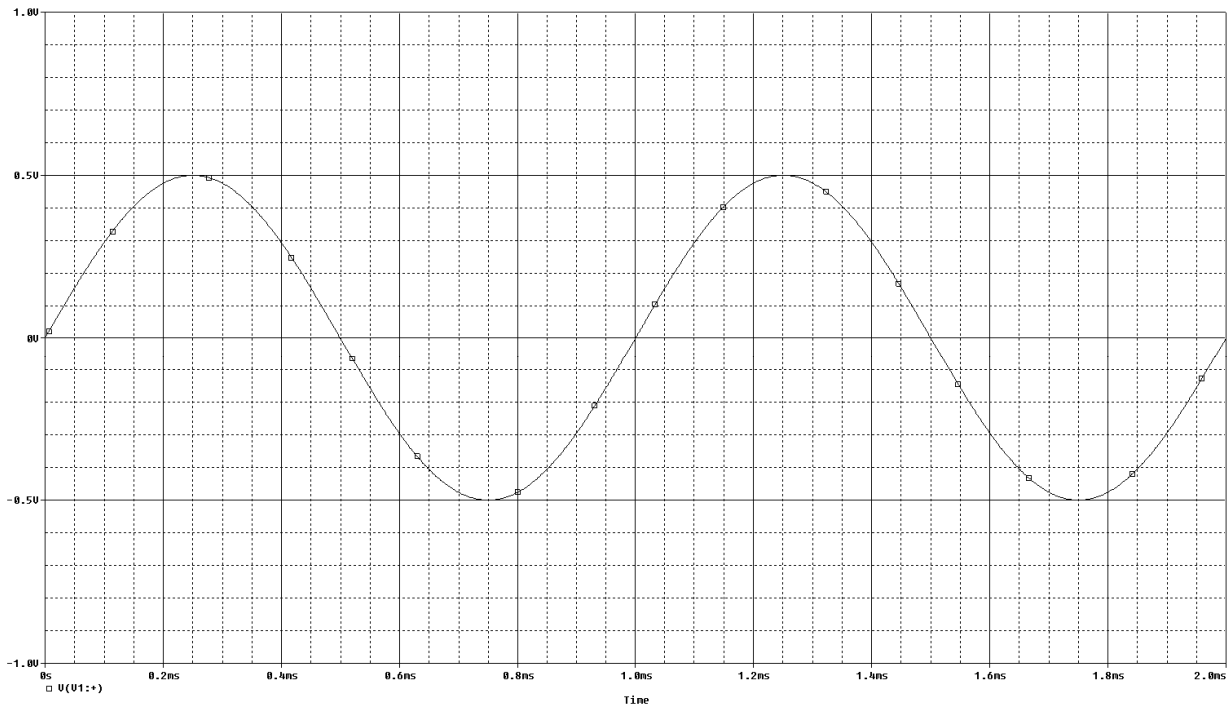
On all questions: SHOW ALL WORK. BEGIN WITH FORMULAS, THEN SUBSTITUTE VALUES AND UNITS. No credit will be given for numbers that appear without justification.

Question I – Diode Limiter Circuits (20 points)



**Diodes turn on at 0.6 volts**

1. (4pt) Draw  $V_{out}$  on the input plot shown below:  $V_{off}=0V$ ,  $V_{amp}=500mV$ ,  $Freq=1k$

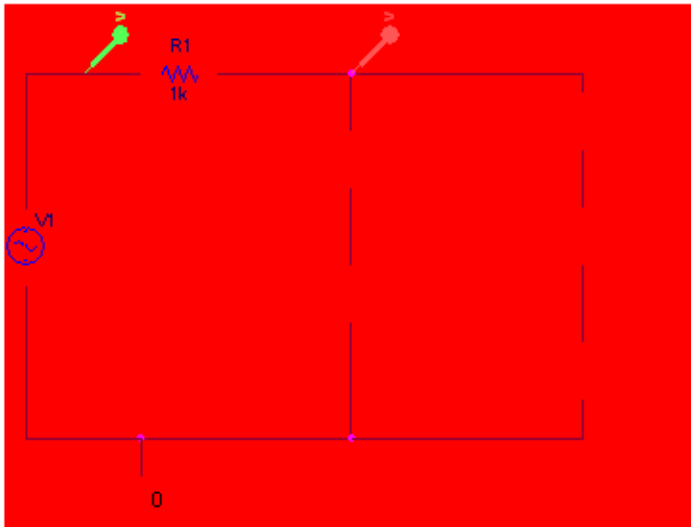


**The output is the same as the input**

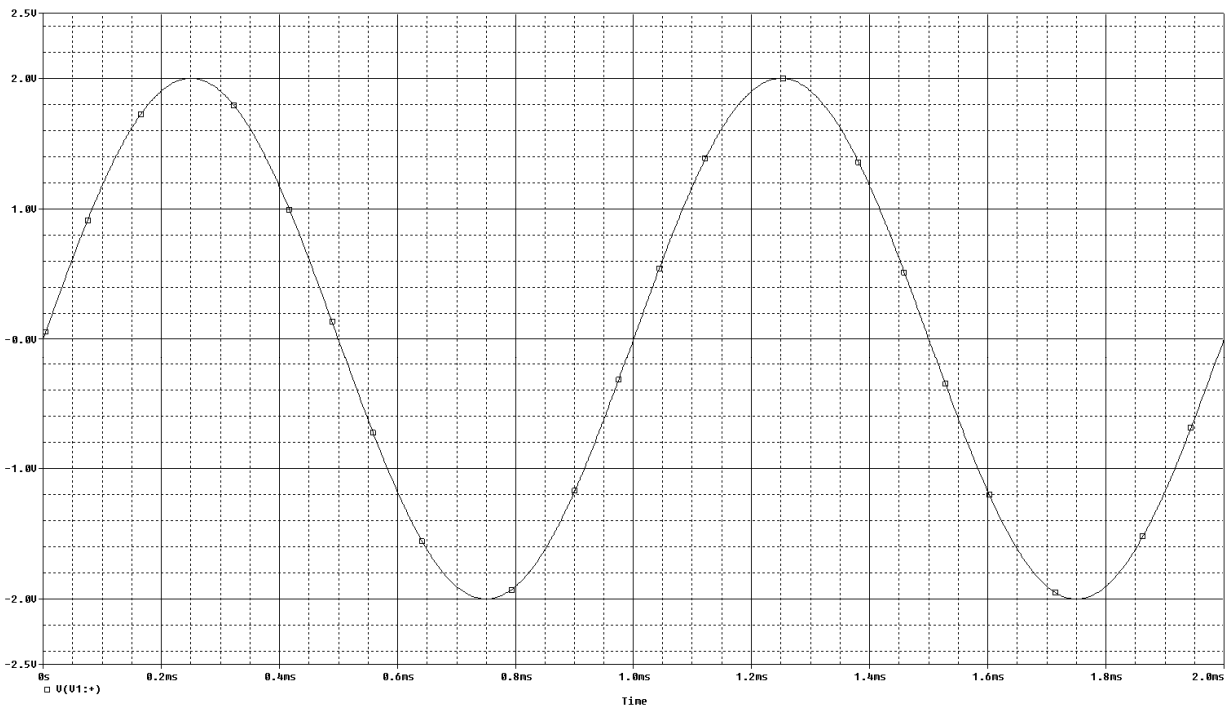
Question I – Diode Limiter Circuits (continued)

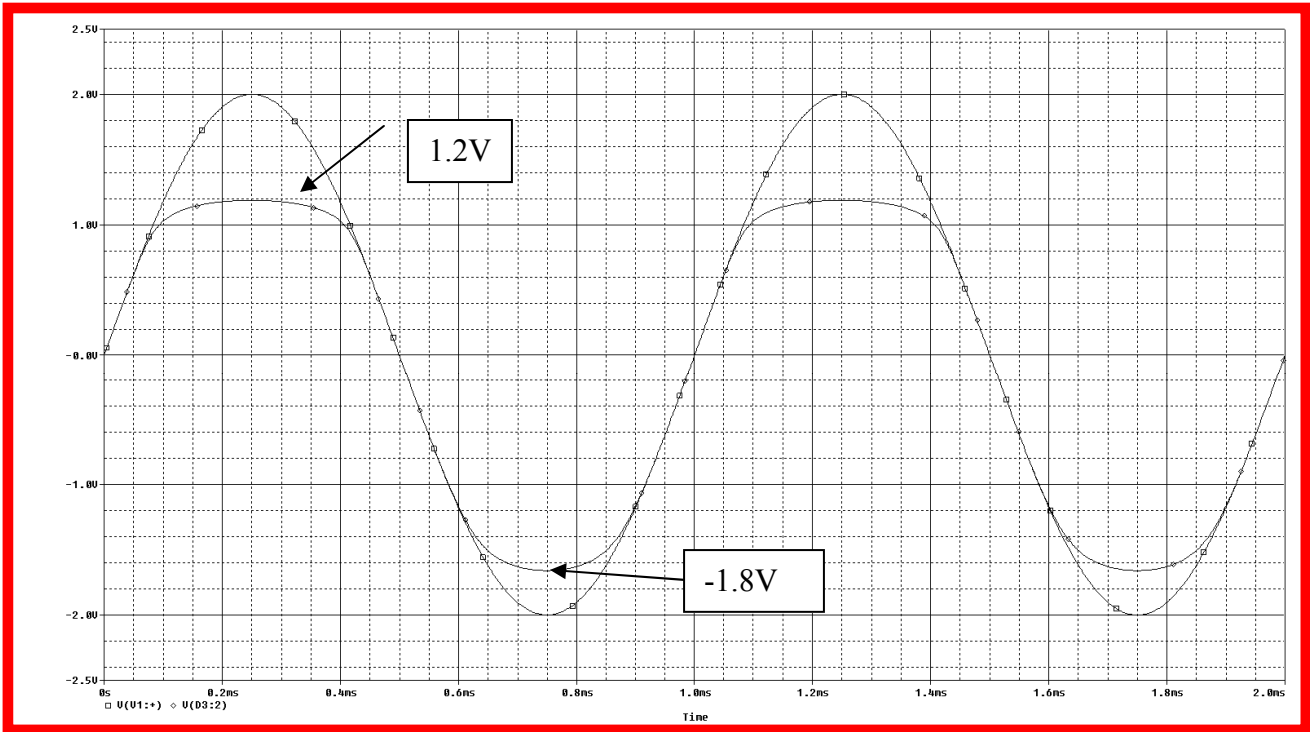
2. (2pt) Draw or explain the reason for the above plot

At +/- 500 mV all diodes are turned off, leaving open circuits. Therefore the output looks the same as the input.



3. (4pt) Draw  $V_{out}$  on the input plot shown below:  $V_{off}=0V$ ,  $V_{amp}=2V$ ,  $Freq=1k$ , (label the maximum and minimum of the output)

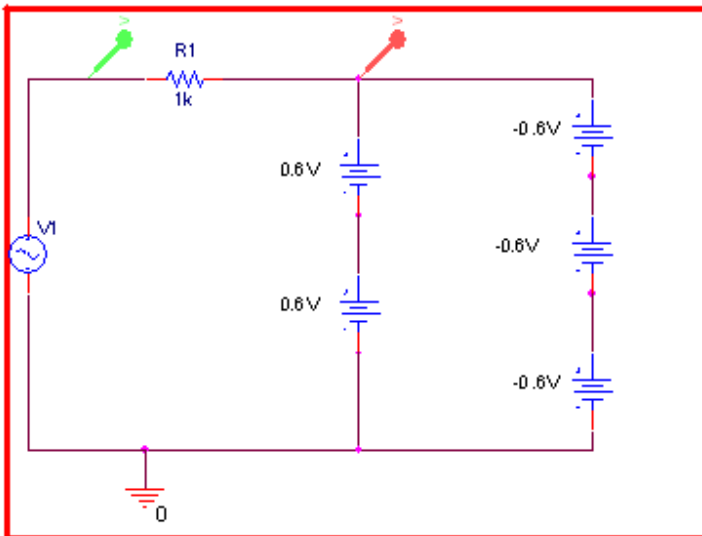




Question I – Diode Limiter Circuits (continued)

4. (2pt) Draw or explain the reason for the above plot

The voltage is limited in the positive voltage to 1.2V and the voltage is limited in the negative voltage to -1.8 V



5. (8pt, 2pt each) What is the value of current through the resistor R1 when the input voltages are the following: (reminder: Assume  $V_{on}$  for each diode is 0.6V)

3 volts:

$$3 \text{ volts} \quad I_{3V} := \frac{3V - 1.2V}{1K\Omega}$$

$$I_{3V} = 1.8 \text{ mA}$$

-3 volts:

$$-3 \text{ volts} \quad I_{3V \text{ minus}} := \frac{-3V - (-1.8V)}{1K\Omega}$$

$$I_{3V \text{ minus}} = -1.2 \text{ mA}$$

0.2 volts:

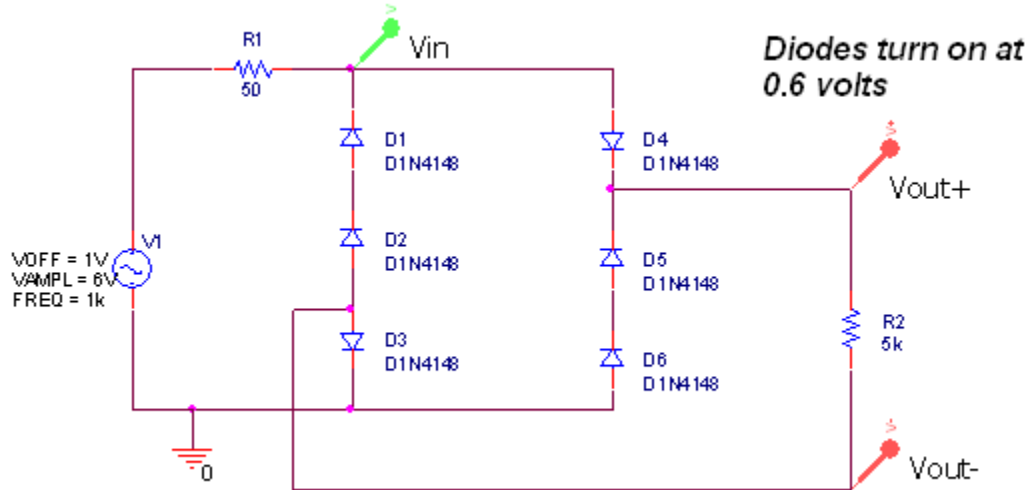
$$0.2 \text{ volts} \quad I_{0.2V} := 0 \text{ mA}$$

$$-0.2 \text{ volts} \quad I_{0.2 \text{ minus}} := 0 \text{ mA}$$

-0.2 volts:

Question II – Diode Rectifier Circuits (20 points)

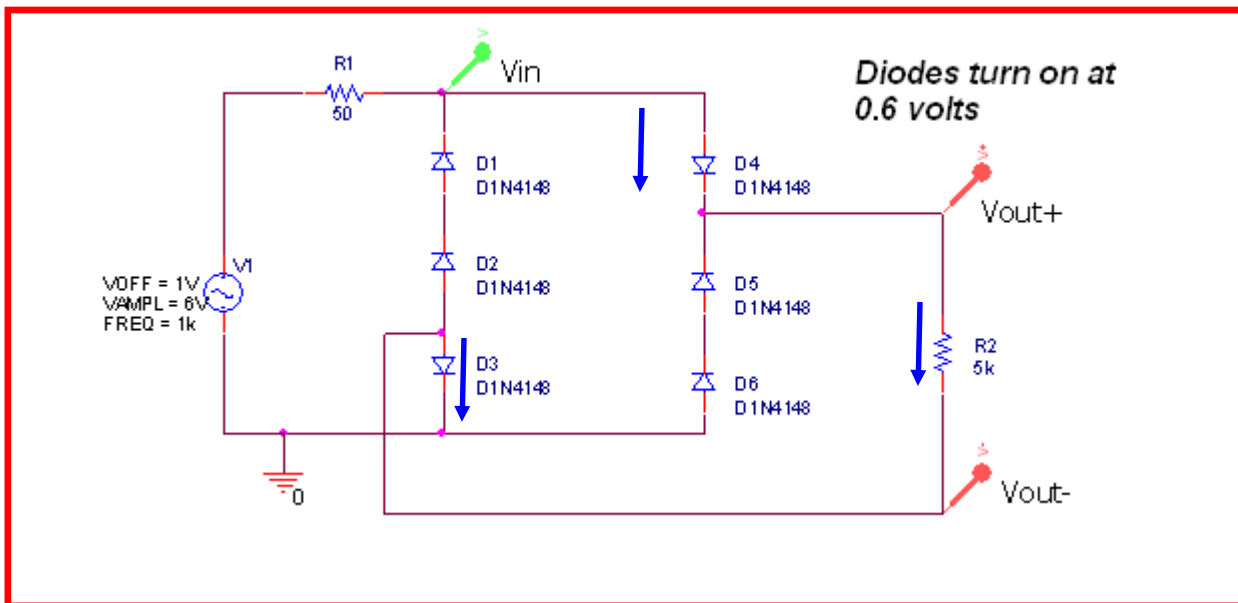
In the rectifier circuit shown below, each of the diodes turn on at **0.6 volts** and the resistances are shown.



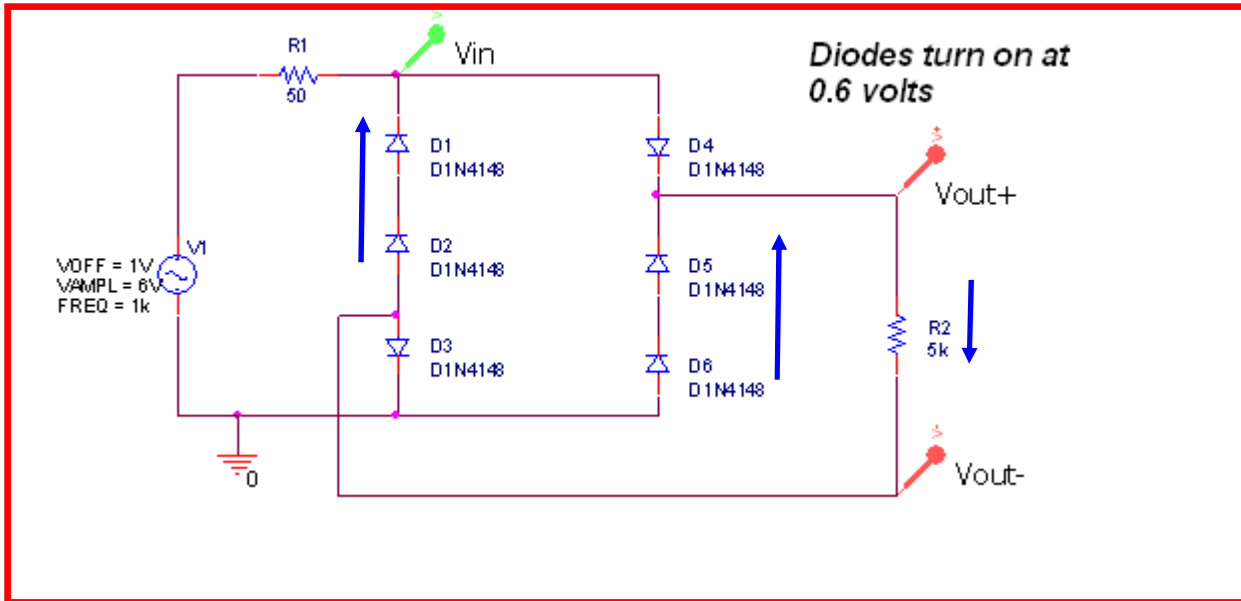
1. (2pt) What type of circuit is it (circle)?

- a) half wave rectifier      b) full wave rectifier      c) voltage limiter      d) not listed: write in as \_\_\_\_\_

2. (3pt) Draw the current direction through the diodes and resistor, R2, for the positive cycle of the voltage input (label on diagram or redraw diagram below)



3. (3pt) Draw the current direction through the diodes and resistor, R2, for the negative cycle of the voltage input (label on diagram or redraw diagram below)



4. (6pt) What will the voltage between Vout+ and Vout- be for the following input voltages:

Vin=7V

Vin = 7 V

$V_{out5} := 7 - 0.6 \cdot 2$

$V_{out5} = 5.8$

Vin=-5V

Vin = -5 V

$V_{out5minus} := 5 - 0.6 \cdot 4$

$V_{out5minus} = 2.6$

Vin=0V

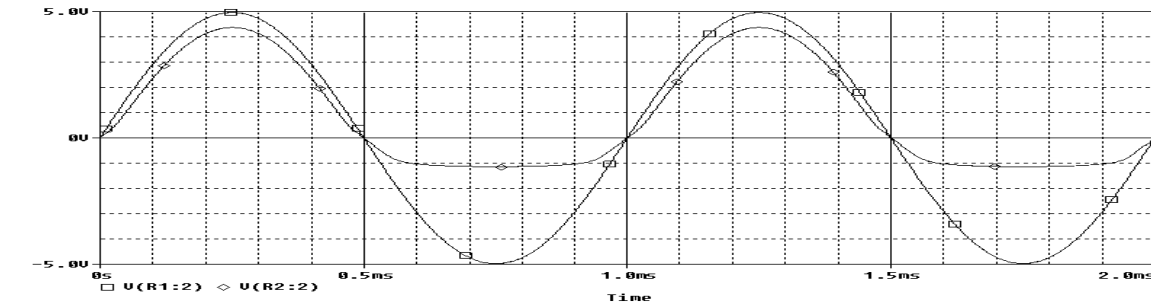
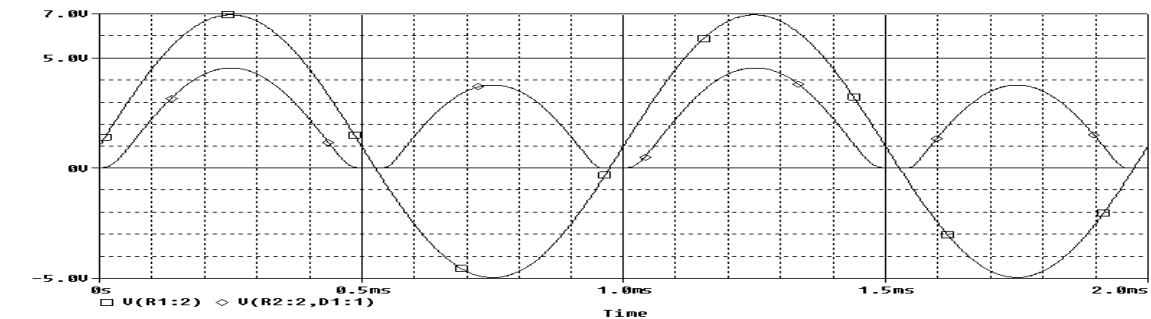
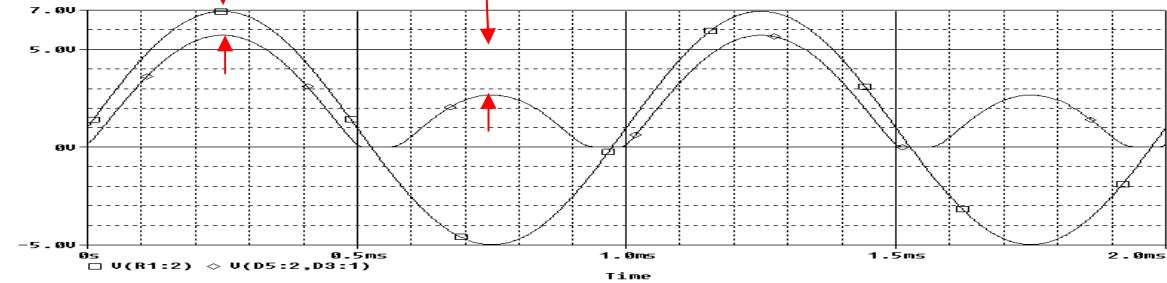
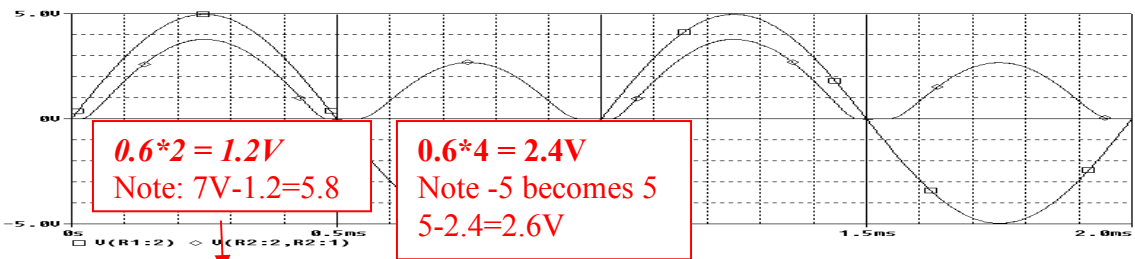
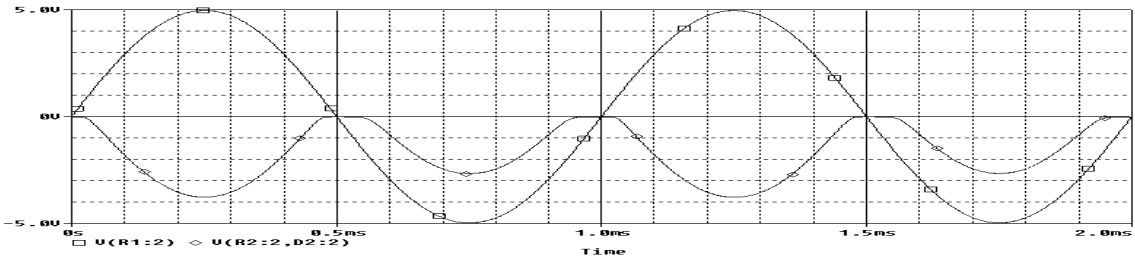
Vin = 0V

$V_{out0} := 0$

Question II – Diode Rectifier Circuits (continued)

5. (4pt) Which of the plots below represent  $V_{in}$  (as specified in the circuit diagram) and  $V_{out+}/V_{out-}$  ?

*Label on the diagram* the value of the *voltage dropped across the diodes* in both the positive and negative portion of the voltage cycle.

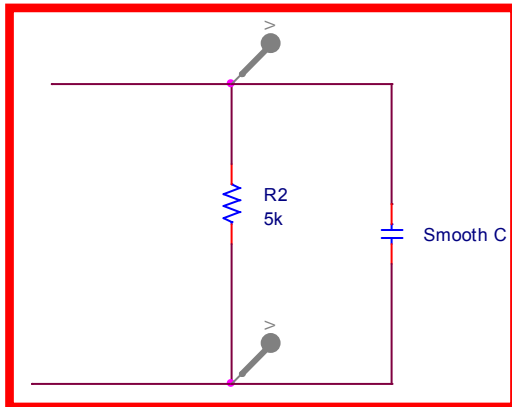




**Question II – Diode Rectifier Circuits (continued)**

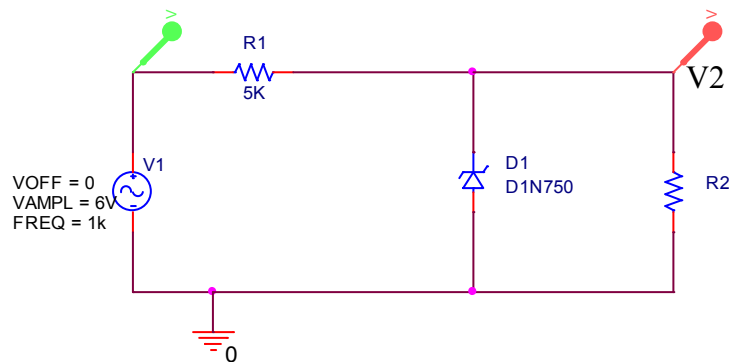
6. (2pt) In general, if you want to convert the AC input into something close to DC (smoothing circuit) where would you place the capacitor? (name correct component(s) in description or draw portion of the circuit responsible for smoothing)

*Why* does a capacitor smooth out the output?



The capacitors store charges from the current due to the voltage across the output. It will then discharge according to its characteristic time. The capacitor can be chosen to have a large time to discharge causing it to smooth the ripple.

## Question III – Zener Diode Circuits (15 points)



The circuit above is a zener diode voltage regulator. Assume the zener voltage of the diode is 4.7 volts and its forward bias voltage is 0.7 volts.

1. (1pt) What does a voltage regulator do? (do not use the word *regulate* in the definition)

It is a circuit which prevents the voltage from exceeding a set voltage limit

2. (6pt) What would the voltage at V2 be when V1=6V if R2 has the following values:

i.) 1 K ohms

$$R2_1 := 1k\Omega$$

$$V1 := 6V$$

$$R1 := 5k\Omega$$

$$V2_1 := \frac{R2_1}{R2_1 + R1} \cdot V1$$

$$V2_1 < 4.7V$$

$$V2_1 = 1V$$

$$V2_{final} = 1V$$

ii.) 10 K ohms

$$R2_{10} := 10k\Omega$$

$$V2_{10} := \frac{R2_{10}}{R1 + R2_{10}} \cdot V1$$

$$V2_{10} < 4.7V$$

$$V2_{10} = 4V$$

$$V2_{final} = 4V$$

iii.) 100 K ohms

$$R2_{100} := 100k\Omega$$

$$V2_{100} := \frac{R2_{100}}{R1 + R2_{100}} \cdot V1$$

$$V2_{100} = 5.714V$$

$$V2_{100} > 4.7V$$

so

$$V2_{final} = 4.7V$$

Question III – Zener Diode Circuits (continued)

3. (6pt) What would the voltage at V2 be when V1 = -6V if R2 has the following values:

i.) 1 K ohms

All -0.7 can be determined by intuition or

ii.) 10 K ohms

iii.) 100 K ohms

i.) 1 K ohms

$$R_{21} := 1k\Omega$$

$$V1 := -6V$$

$$V_{21} := \frac{R_{21}}{R_1 + R_{21}} \cdot V1$$

$$V_{21} = -1V \quad -1V < -0.7V$$

$$V_{2final} = -0.7V$$

ii.) 10 K ohms

$$R_{210} := 10k\Omega$$

$$V_{210} := \frac{R_{210}}{R_{210} + R_1} \cdot V1$$

$$V_{210} = -4V \quad -4V < -0.7V$$

$$V_{2final} := -0.7V$$

iii.) 100 K ohms

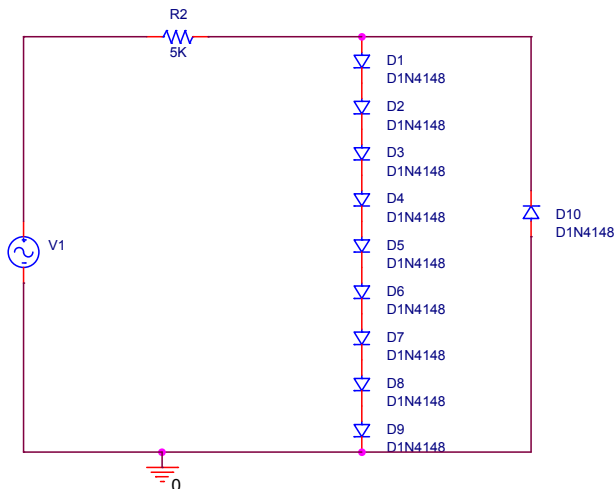
$$R_{2100} := 100k\Omega$$

$$V_{2100} := \frac{R_{2100}}{R_{2100} + R_1} \cdot V1$$

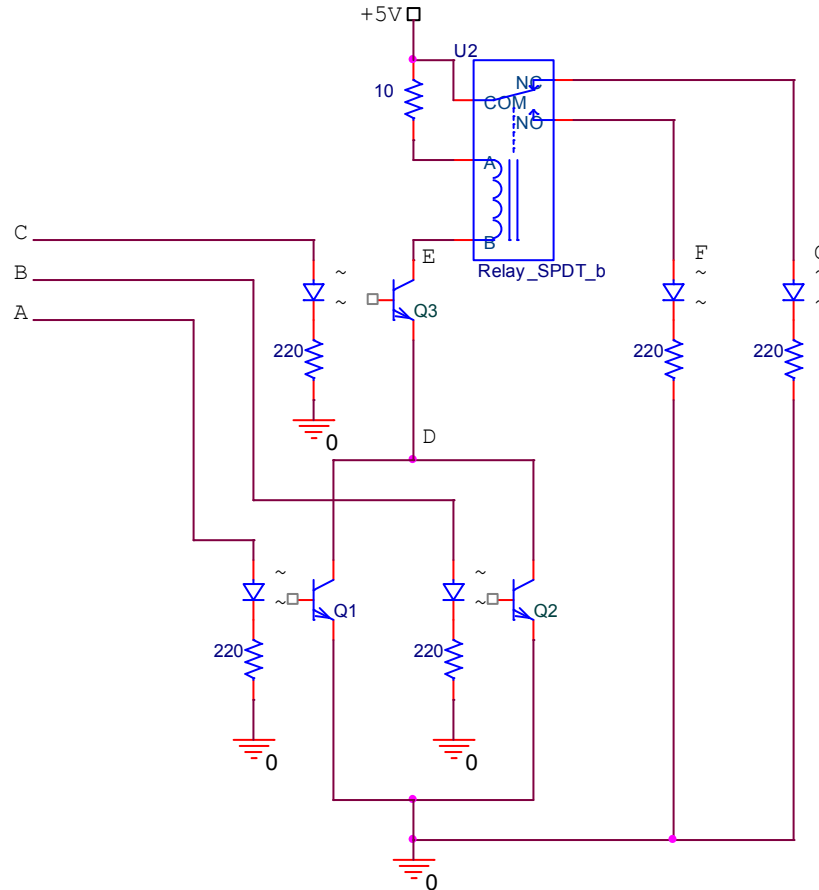
$$V_{2100} = -5.714V \quad -5.714V < -0.7V$$

$$V_{2final} := -0.7V$$

4. (2pt) Complete the following circuit to mimic within ±0.1V a zener voltage of 5.4V and a turn on voltage of 0.65V using a number of D1N4148 “regular” diodes (turn on voltage 0.6V).



## Question IV - LEDs and Phototransistor Circuits (20 points)



Above is an optical isolation circuit with LED/phototransistor pairs. The inputs may be in a cage whose reference voltage is 5kV higher than the phototransistor and relay circuit, but the “optical isolation” removes the danger of high voltage getting through. The on resistance of the phototransistors is  $20\Omega$  and the resistance of the coil is negligible, although 50mA is needed to turn on the relay.

1. (3pt) Given that inputs A, B & C are such that Q2 & Q3 are fully on and Q1 is off, find the current through the coil.

$$\text{Answer: } R = 10 + 20 + 20 = 50$$

$$I = 5/50 = 100\text{mA}$$

2. (3pt) Given that inputs A, B & C are such that all the phototransistors Q1, Q2 & Q3 are fully on, find the current through the coil.

$$\text{Answer: } R = 10 + 20 + (20||20) = 10 + 20 + 10 = 40$$

$$I = 5/40 = 125\text{mA}$$

## Question IV - LEDs and Phototransistor Circuits (continued)

3. (8pt) Fill in the following table:

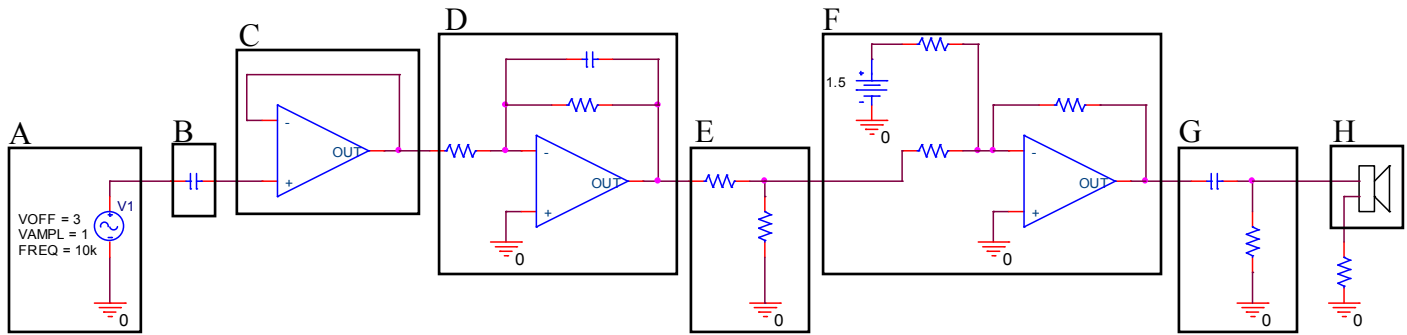
C	B	A	LED F (on or off?)	LED G (on or off?)
0V	0V	0V	OFF	ON
0V	0V	5V	OFF	ON
0V	5V	0V	OFF	ON
0V	5V	5V	OFF	ON
5V	0V	0V	OFF	ON
5V	0V	5V	ON	OFF
5V	5V	0V	ON	OFF
5V	5V	5V	ON	OFF

4. (4pt) Assuming phototransistor Q1 & Q3 are on and Q2 is off, what is the voltage at D in the circuit above?

$$\text{Answer: } V = 5(20)/(10 + 20 + 20) = 2V$$

5. (2pt)  TRUE or FALSE: The Boolean logic expression for LED F being on (or TRUE) is:  $C \bullet (B+A)$ .

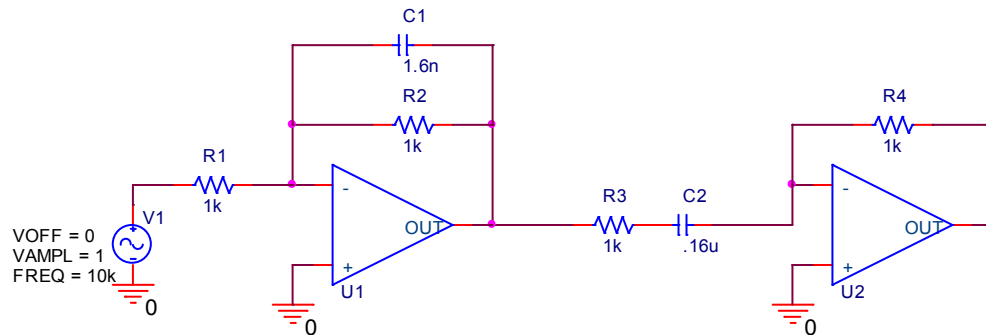
Question V – Signal Modulation and Functionality (25 points)



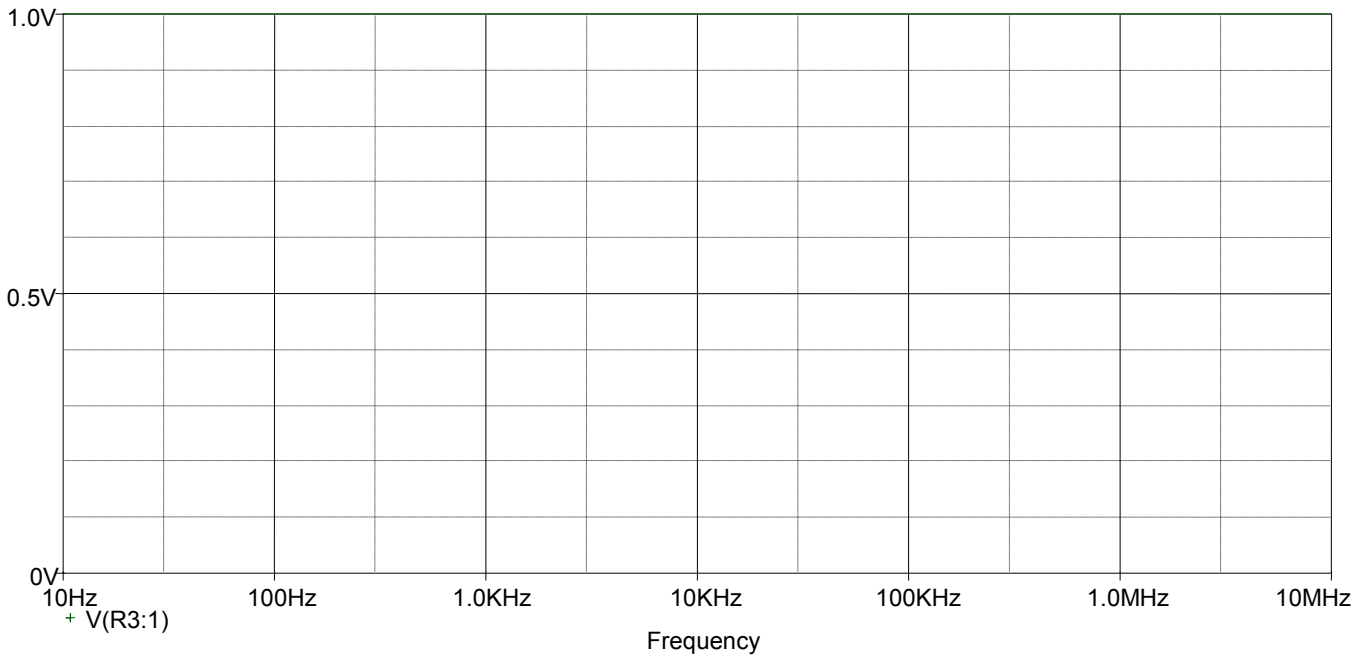
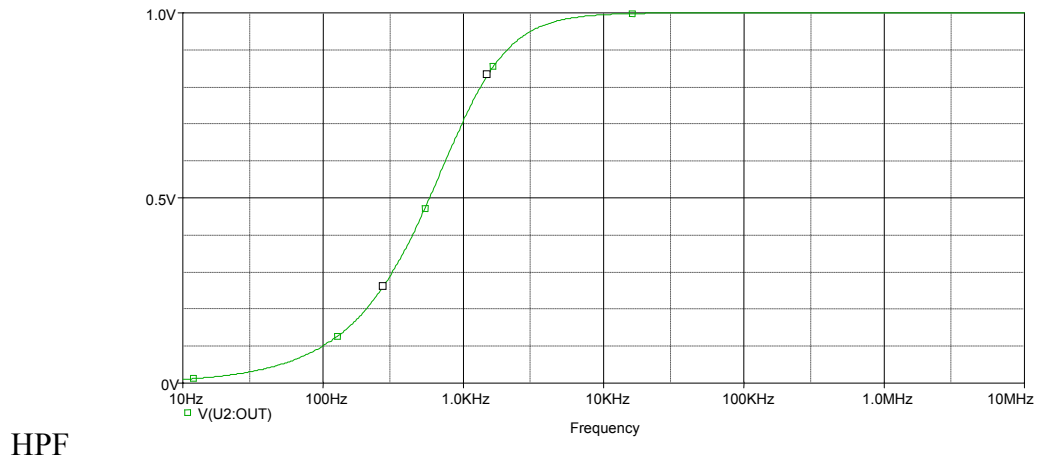
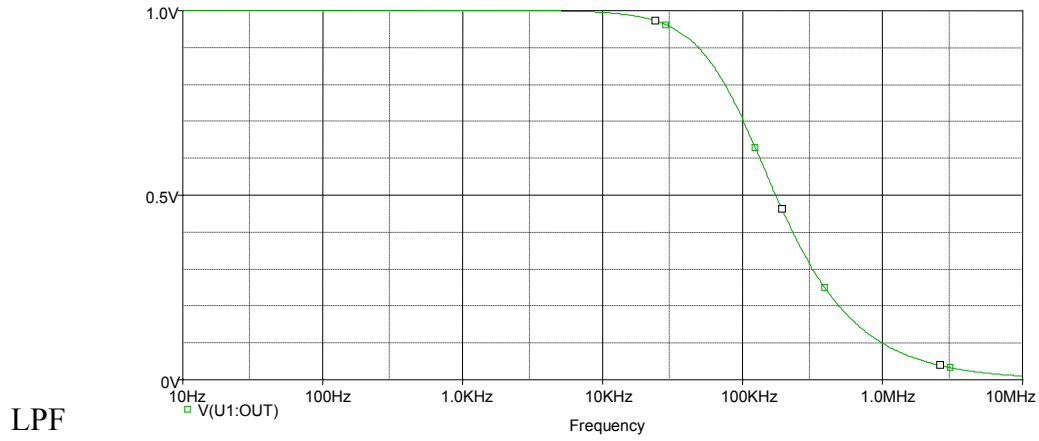
1. (8pt) Identify the function of each of the blocks in the signal conditioning circuit above.

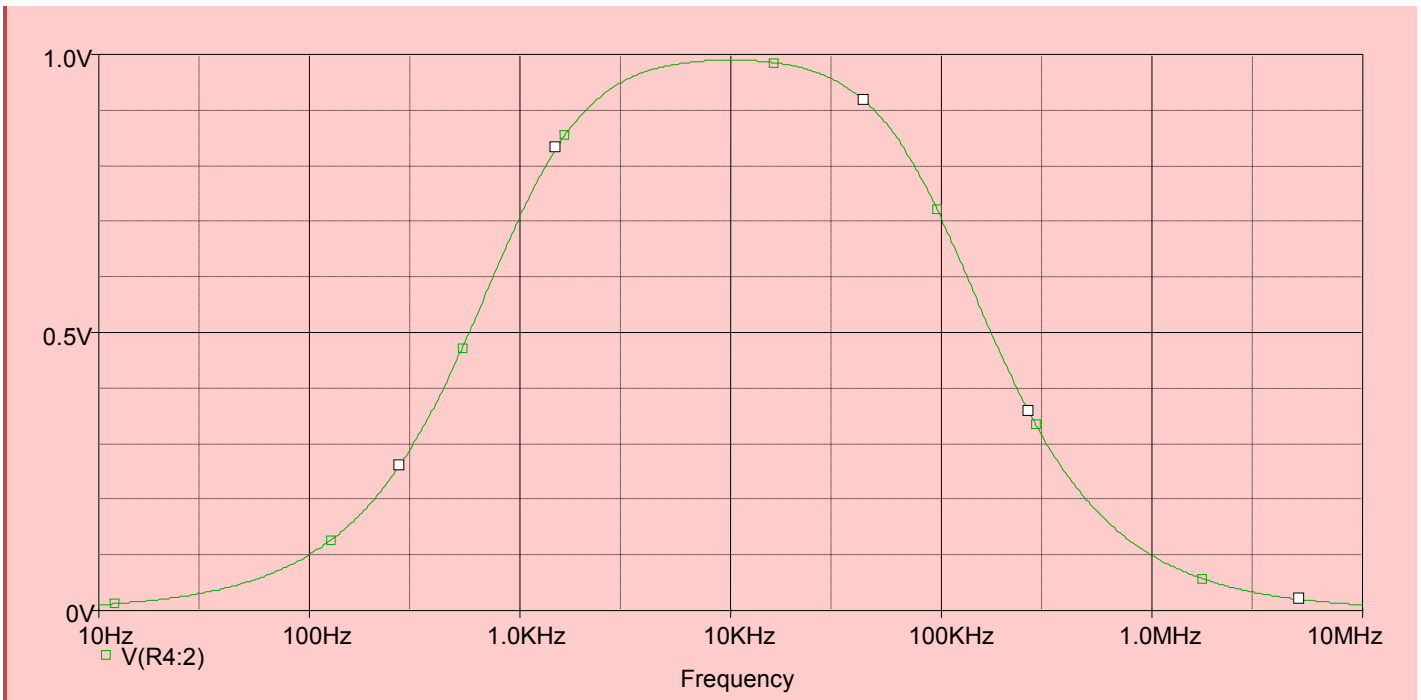
A: <b>Signal input or source</b>	E: <b>Voltage divider</b>
B: <b>DC Blocking capacitor</b>	F: <b>Summing amp or Adder</b>
C: <b>Buffer or Unity gain amp</b>	G: <b>High pass filter (passive)</b>
D: <b>Low pass filter or Miller Integrator</b>	H: <b>Output speaker</b>

2. (5pt) The following filter consists of a LPF in series with a HPF. The responses of each block are shown. Sketch the response of the combined blocks on the third axes below.



Question V – Signal Modulation and Functionality (continued)







**Question V – Signal Modulation and Functionality (continued)**

3. (6pt) The input to the circuit in 2 is a sine wave whose amplitude is 1V. Find the approximate amplitude of the output sine wave by inspection of the plots above for the following frequencies: 300Hz, 10kHz, & 100kHz. (HINT: remember the frequency axis is a LOG scale.)

a) 300Hz

$$|H_{\text{LPF}}(300)| = 1 \quad |H_{\text{HPF}}(300)| = 0.3 \quad V_{\text{out}} = V_{\text{in}} \times |H_{\text{LPF}}| \times |H_{\text{HPF}}| = 0.3\text{V}$$

b) 10kHz

$$|H_{\text{LPF}}(10\text{k})| = 1 \quad |H_{\text{HPF}}(10\text{k})| = 1 \quad V_{\text{out}} = V_{\text{in}} \times |H_{\text{LPF}}| \times |H_{\text{HPF}}| = 1.0\text{V}$$

c) 100kHz

$$|H_{\text{LPF}}(100\text{k})| = 0.7 \quad |H_{\text{HPF}}(100\text{k})| = 1 \quad V_{\text{out}} = V_{\text{in}} \times |H_{\text{LPF}}| \times |H_{\text{HPF}}| = 0.7\text{V}$$

4. (4pt) If the circuit in 2 were to be used as part of a demodulation system to recover an input signal that had been modulated (new frequencies added that were not part of the original signal), where in the frequency plot (frequency spectrum) should the original signal be located to guarantee that as little as possible of the original signal is lost in the process.

The center of the Band Pass Filter is 10kHz. The original signal should be centered around 10kHz.

5. (2pt)  TRUE or FALSE: Given the same corner frequency and gain, there is no difference between a Miller Integrator and a first order Low Pass Filter.