ENGR-4300
Fall 2007
Test 4

Name _____SOLUTION_____

Section 1(MR) 2(TF)
(circle one)

Question I (22 points) _____

Question II (18 points) _____

Question III (20 points) _____

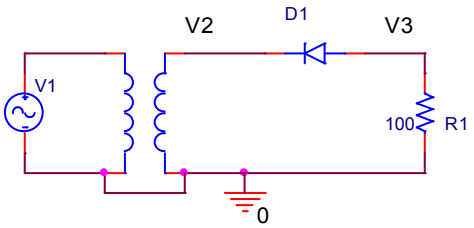
Question IV (22 points) _____

Question V (18 points) _____

Total (100 points): _____

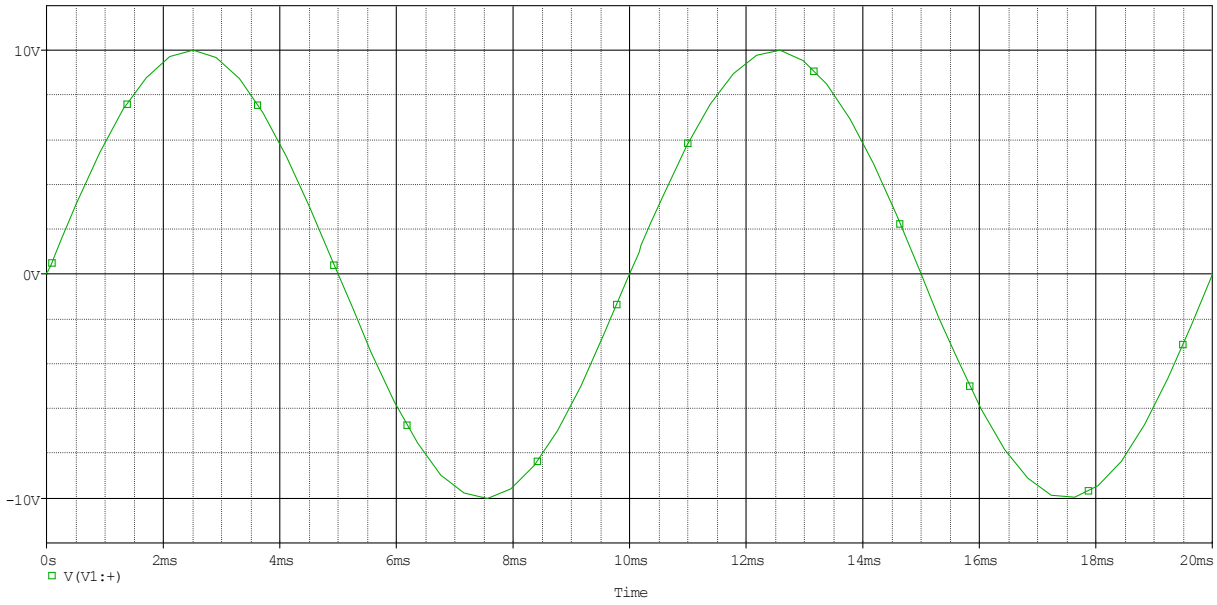
On all questions: SHOW ALL WORK. BEGIN WITH FORMULAS, THEN SUBSTITUTE VALUES AND UNITS. No credit will be given for numbers that appear without justification.

Question I – Diode Rectifier Circuits (22 points)



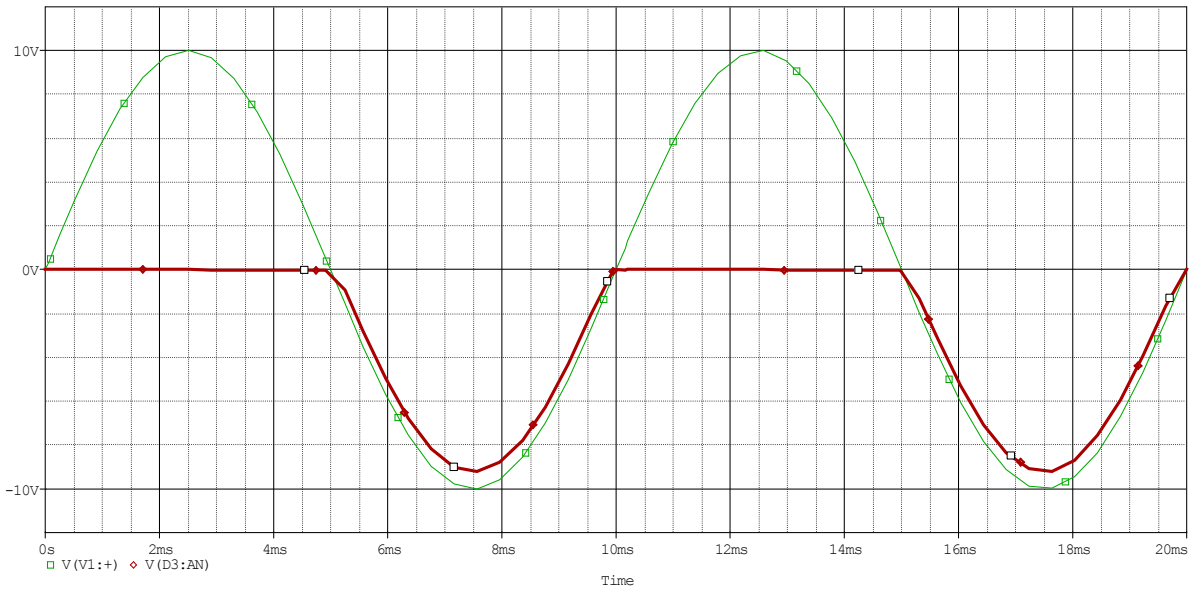
The diagram above shows the application of a diode for performing rectification of the signal from the output of the transformer. The sinusoidal source of voltage (V2) has VAMP = 10V and FREQ = 100Hz. Assume that the idealized diode has 0.7V across it during turn-on.

1. (4pt) Sketch V3, given V2, in the figure below:

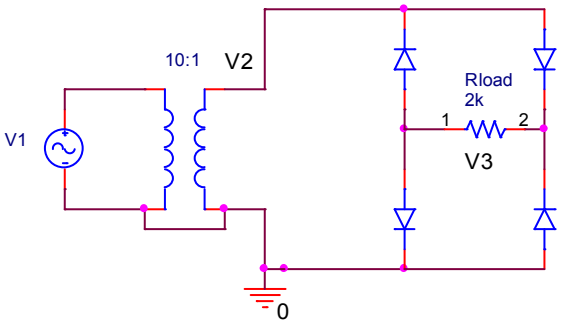


2. (1pt) If V1 has an amplitude of 120V, is the transformer a step-up or a step-down transformer?

Step-down: 120V → 10V


10V
0V
-10V
0s
2ms
4ms
6ms
8ms
10ms
12ms
14ms
16ms
18ms
20ms
V(V1:+)
V(D3:AN)
Time

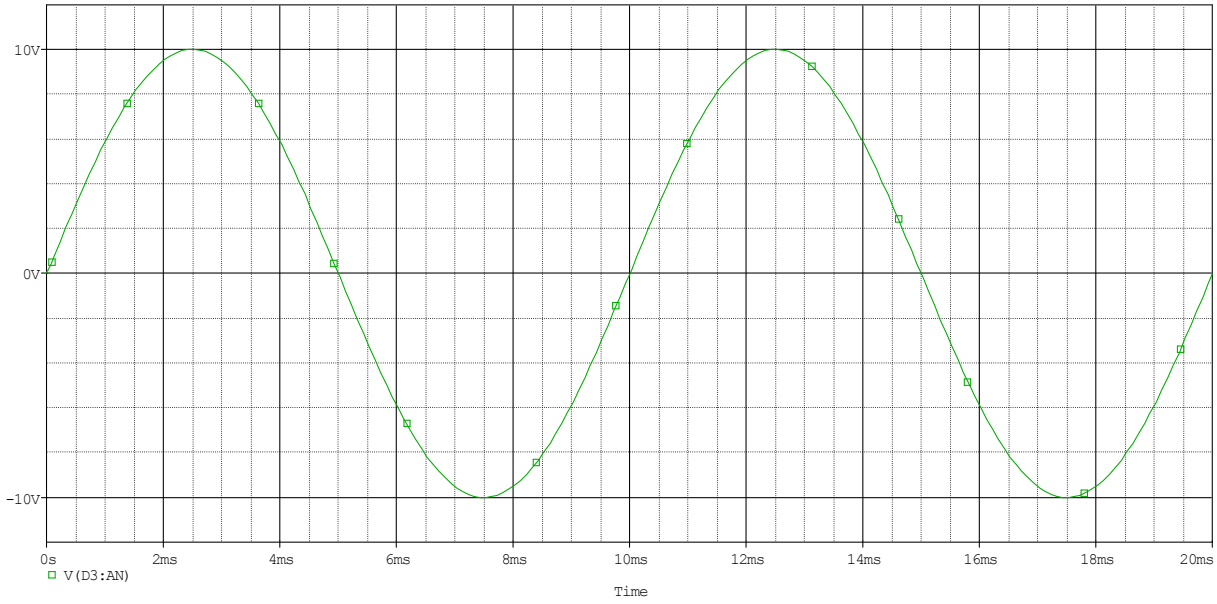
Question I – Diode Rectifier Circuits (continued)



3. (2pt) Now a full wave diode bridge replaces the single diode. Which terminal of Rload, 1 or 2, will have the positive (high) voltage?

Terminal 2 is +

4. (4pt) These diodes have the same 0.7V across them when conducting. Given V2 is a 10V sine wave with a frequency of 100Hz, plot the differential voltage across Rload on the axes below.



5. (3pt) What is the peak voltage across Rload?

Vpeak = 10 – 0.7 -0.7 = 8.6V

Question I – Diode Rectifier Circuits (continued)

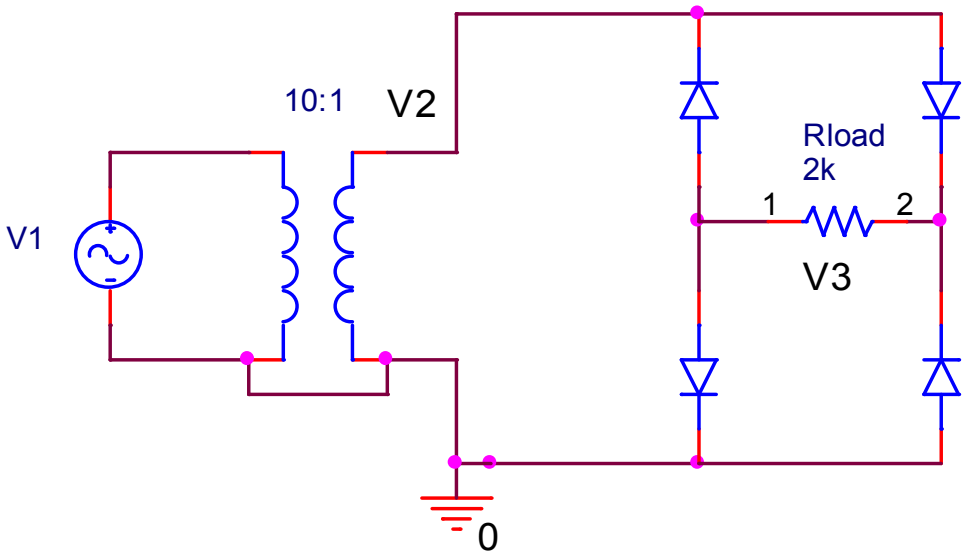
6. (2pt) If Rload = 2k, what is the maximum (peak) current through it?

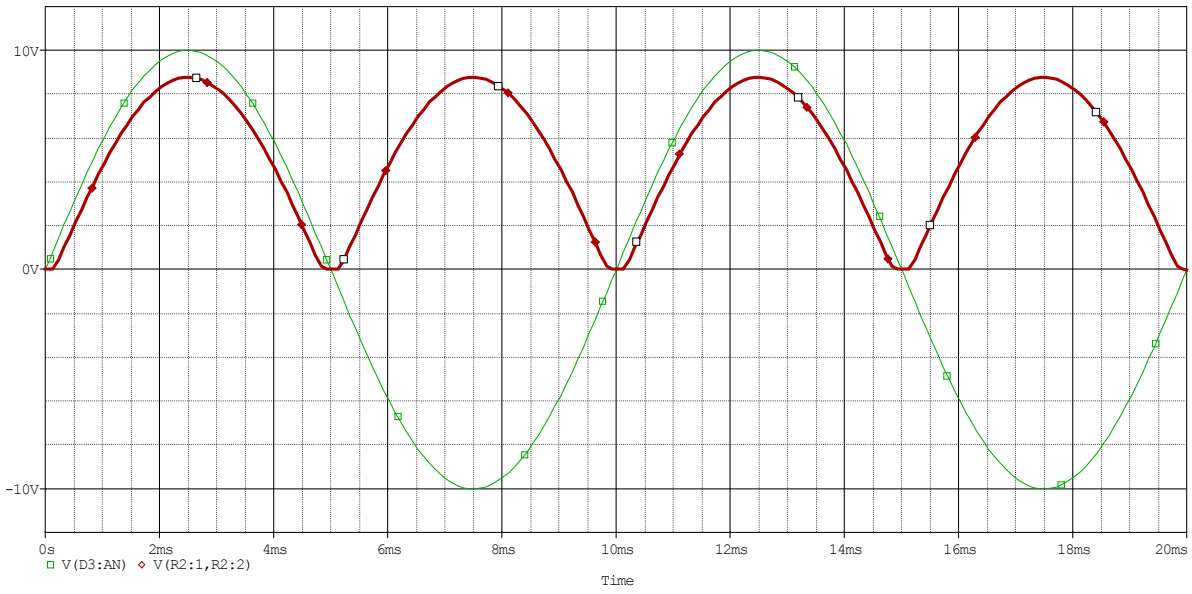
Imax = Vpeak/2k = 8.6/2k = 4.3mA

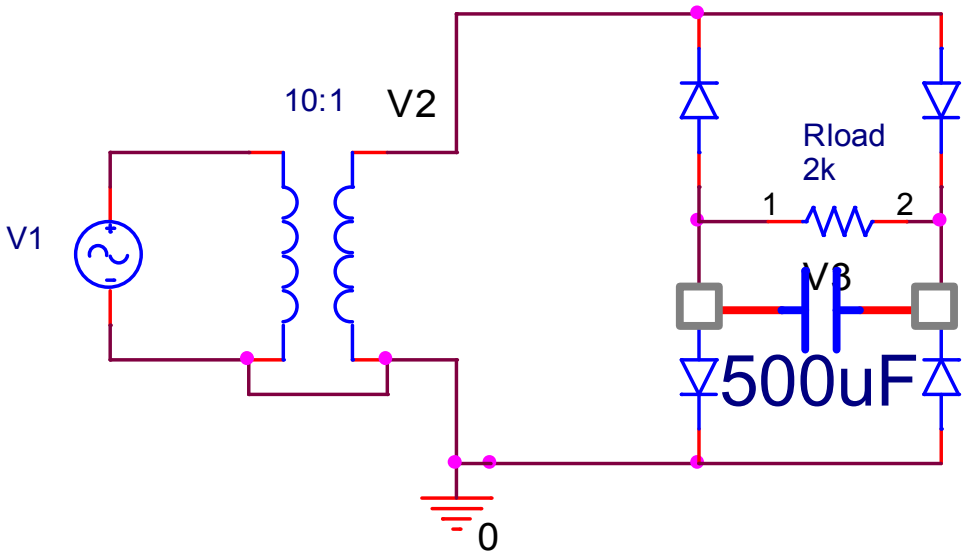
7. (3pt) Given V2 above, what must the amplitude of V1 be to provide this output from the transformer?

V1 = V2(N1/N2) = 10(10/1) = 100V

8. (3pt) Add a 500µF capacitor to the circuit in 3. (redrawn below) between appropriate nodes to reduce the ripple (voltage variations) on Rload.

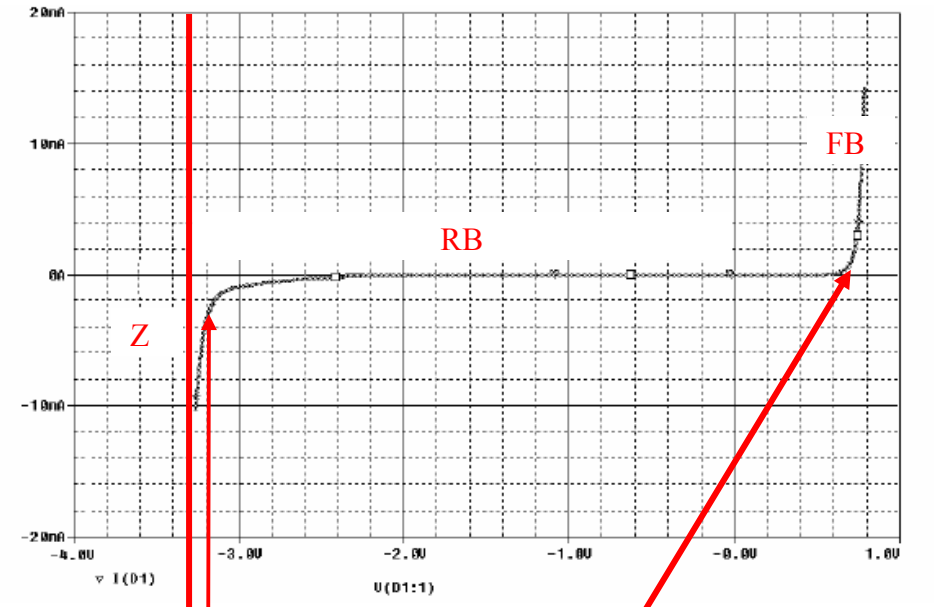



10V
0V
-10V
0s
2ms
4ms
6ms
8ms
10ms
12ms
14ms
16ms
18ms
20ms
V(D3:AN)
V(R2:1,R2:2)
Time


10:1
V2
V1
Rload
2k
1
2
V3
500uF
0

Question II – Zener Diode Circuits (18 points)

Characteristic curve: The following plot shows the characteristic curve for a Zener diode.



1. (3pt) Mark the following regions on the plot by indicating the boundaries on the x-axis:
Forward bias region Reverse bias region Zener region

2. (6) Find the following values and indicate where they are on the plot:

a) Zener Voltage

3.3V

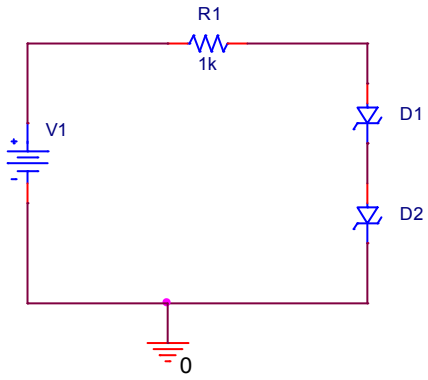
b) Knee current (current at the point where the voltage across the diode is within 0.1V of the Zener voltage)

-3.5mA

c) Turn on voltage

0.7V

Question II – Zener Diode Circuits (continued)



3. (6pt) Using the Zener voltage found above, what region will each Zener diode be in, Forward Bias (FB), Reverse Bias (RB), or Zener (Z), when the voltage at V1 is each of the following?

Upper Limit = 2(0.7V0 = 1.4V Lower Limit = 2(-3.3V) = -6.6V

Diode is off for -6.6V < Vd < 1.4V

V1 voltage	D1 Region	D2 Region
-7.5 V	Z	Z
-3.5 V	RB	RB
-1.0 V	RB	RB
1.5 V	FB	FB
3.5 V	FB	FB
7.5 V	FB	FB

4. (3pt) What will the current through the circuit be when the voltage at the input is the following?

a) -7.5V:

[-7.5V – (2 x -3.3V)]/1kΩ = [-0.9V]/1kΩ = -0.9mA

b) 1.0V:

1V < (2 x 0.7V) = 1.4V diode is turned off: current = 0.0mA

c) 3.5V:

[3.5V – (2 x 0.7V)]/1kΩ = [2.1V]/1kΩ = 2.1mA

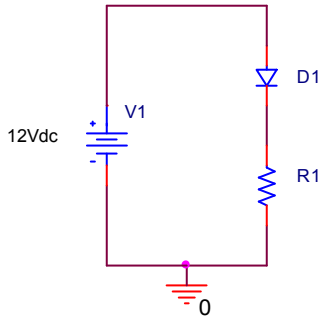
Question III – LEDs and Phototransistor Circuits (20 points)

A high brightness LED is to be driven by a standard DC source. The source we have available is a 12 Volt wall wart capable of producing up to 6 Watts. We wish to drive this LED in what is called the torch mode, with the high light output required to use it in a flashlight. For this kind of operation, we need a forward bias voltage of 5V and a current of 100mA.

1. (4pt) What is the maximum current that this power supply can produce at its rated voltage? We will need this information for part of this problem.

Answer: I is 6/12 = 500mA

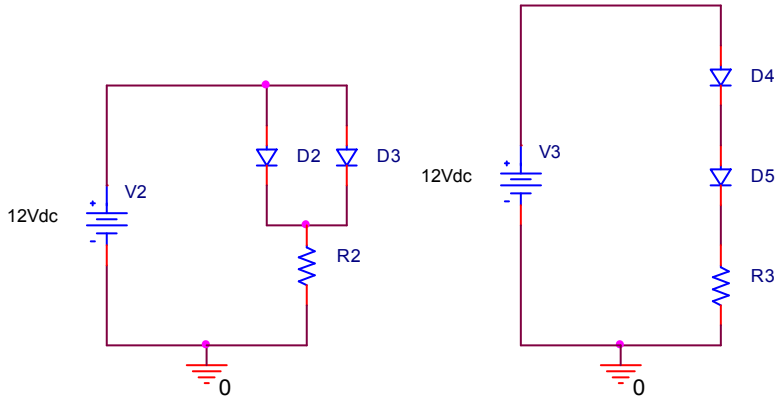
2. (6pt) Using the 12V power supply, determine the resistance R1 necessary to achieve the desired operating conditions for the diode. Also, determine the power dissipated in the diode D1 and the resistor R1.



Answer: $R1 = \frac{12-5}{0.1} = 70\Omega$ *The power in the diode is* $P = 5(.1) = 500mW$ *while the power in the resistor is* $P = 7(.1) = 700mW$

Question III – LEDs and Phototransistor Circuits (continued)

3. (8pt) Now, we wish to use this supply to power as many of these diodes as possible. We can either connect them all in series or all in parallel. Shown below are the two options for two diodes. Find the configurations that support the largest number of diodes in both parallel and series. That is, determine R2 or R3 for the two cases and the power dissipated in both the diodes and the resistors.



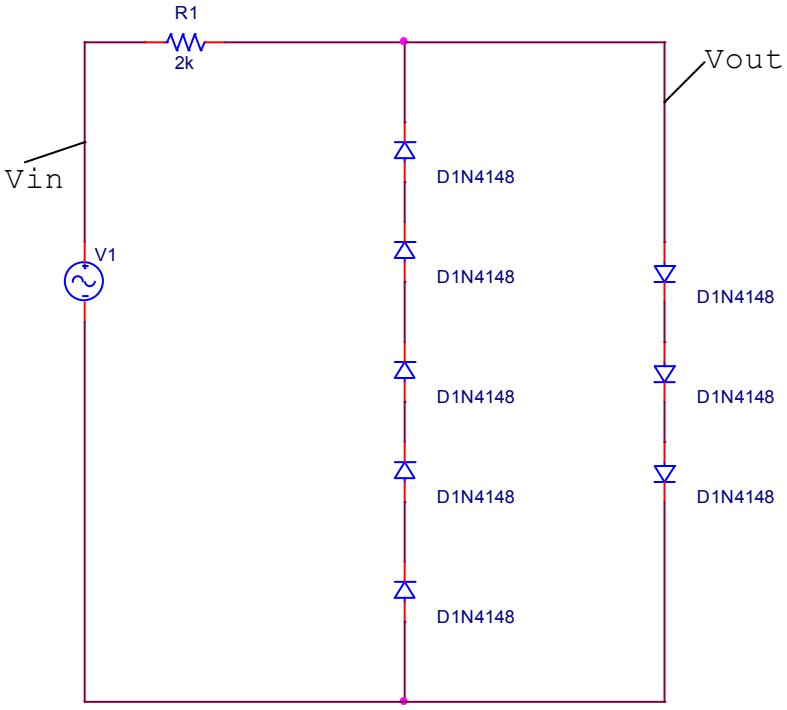
Answer: For the parallel combination, each of the diodes must have a current of 100mA, so it seems that 5 diodes can be supported this way. The resistor then is $R2 = \frac{12-5}{0.5} = 14\Omega$ *. The power in the diodes is* $P = 5(5)(.1) = 2.5W$ *and the power through the resistor is* $P = 7(.5) = 3.5W$ *so we just make the 6W limit. The resistor might not like the 3.5W, but we can just add up a bunch of them to get the required power handling. For the series combination, we can only support 2 diodes since each requires 5V, and the resistor is* $R3 = \frac{12-10}{0.1} = 20\Omega$ *. The power in the diodes is* $P = 2(5)(.1) = 1W$ *while the power in the resistor is* $P = 2(.1) = 200mW$ *.*

4. (2pt) Which configuration allows for the maximum number of diodes to be powered by this source?

Clearly the parallel case is better since more diodes can be supported within both the voltage and power limits.

Question IV - Diode Limiter Circuits (22 points)

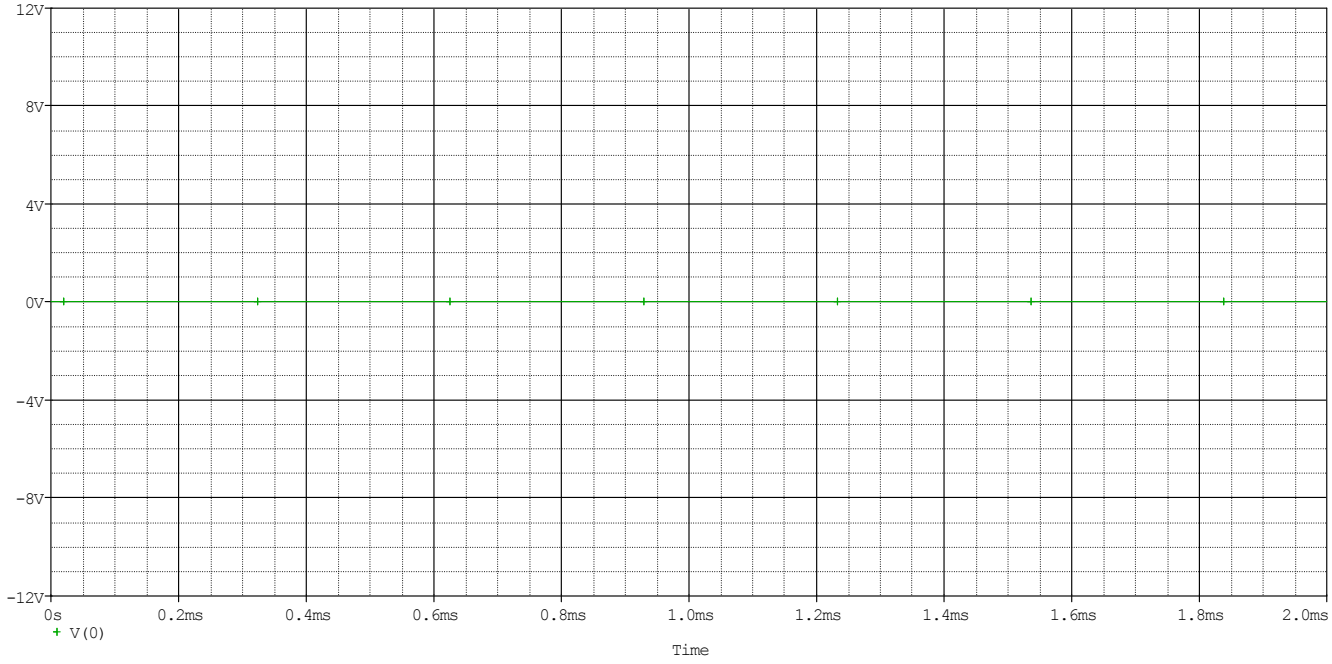
You are given the following circuit:



1. (4pt) What are the minimum and maximum voltages that can ever occur at Vout?

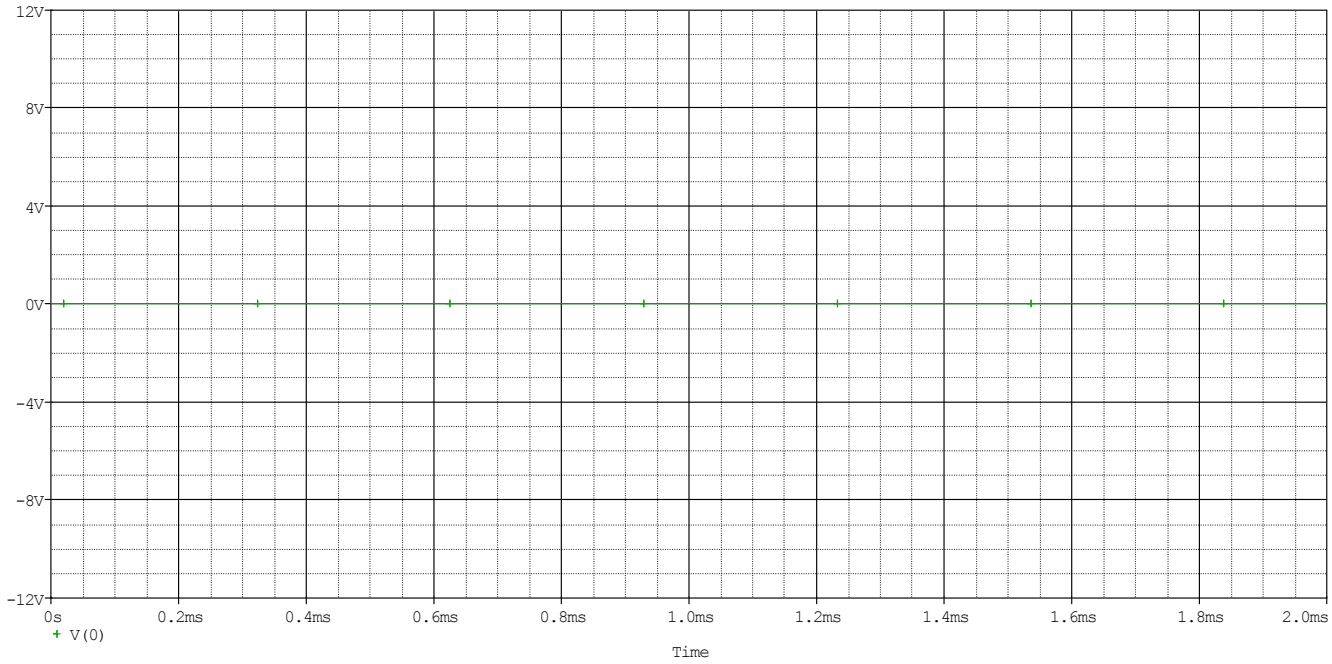
Vmin = -0.7V x 5 = -3.5V
Vmax = +0.7V x 3 = +2.1V

2. (5pt) Sketch Vin and Vout when V1 has: VAMPL = 5V, VOFF = 0V, FREQ = 1kHz.

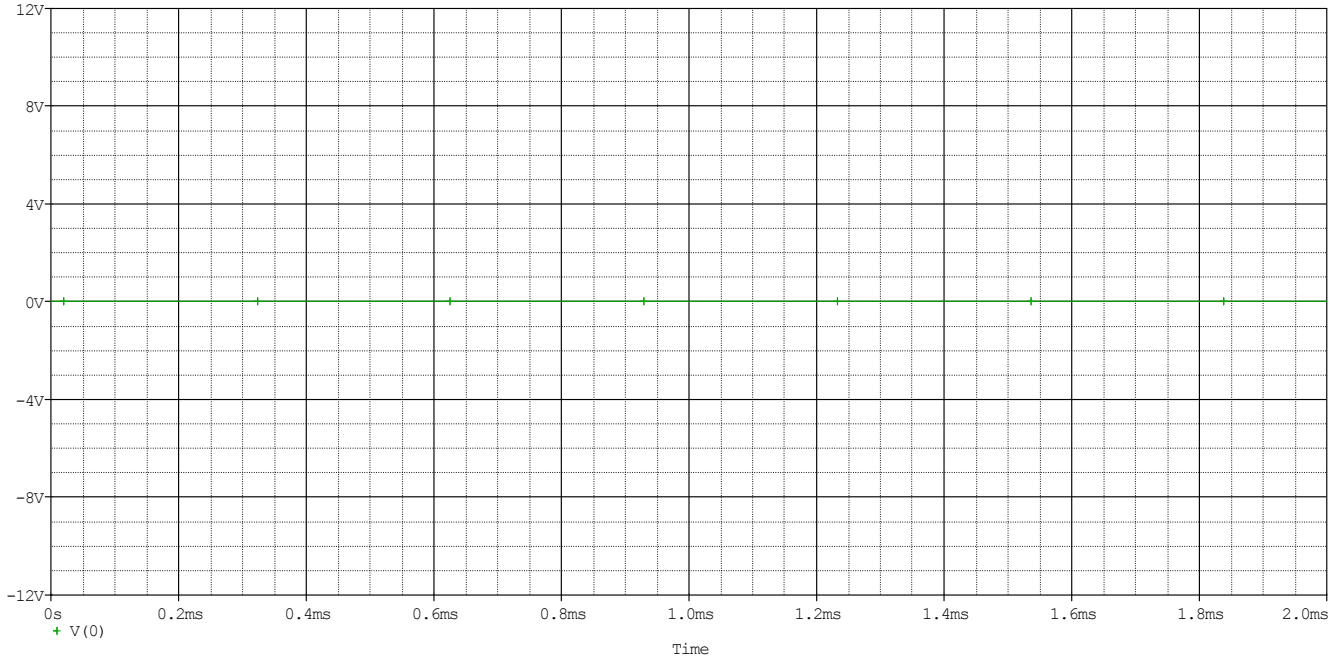


Question IV - Diode Limiter Circuits (continued)

3. (5pt) Sketch Vin and Vout when V1 has: VAMPL = 5V, VOFF = 2V, FREQ = 500Hz.

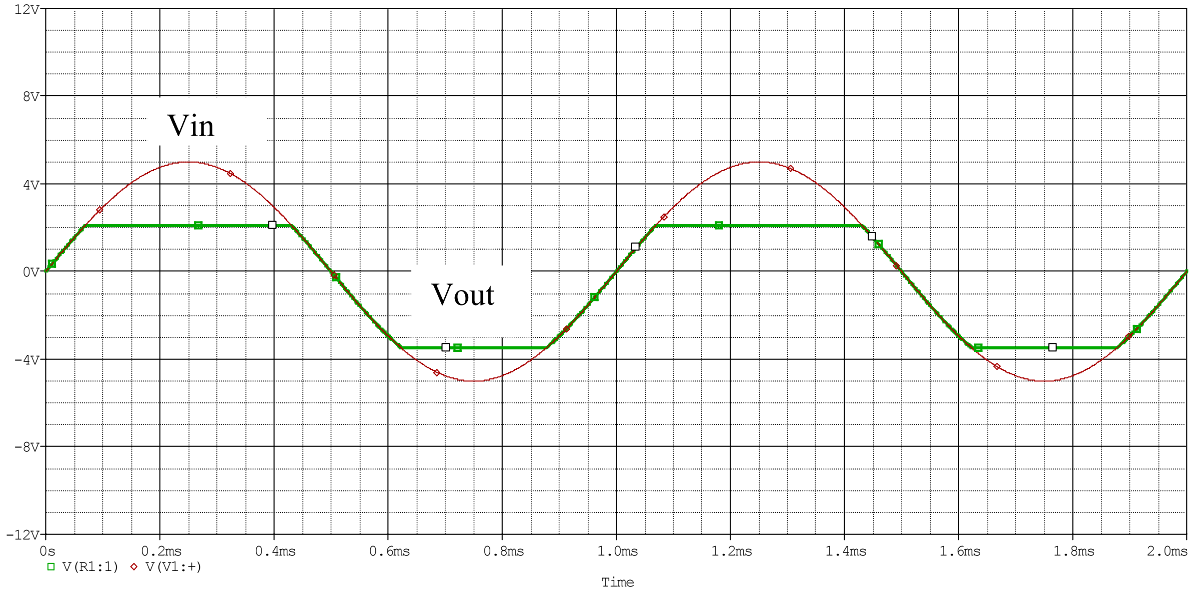


4. (5pt) Sketch Vin and Vout when V1 has: VAMPL = 5V, VOFF = -2V, FREQ = 2kHz.

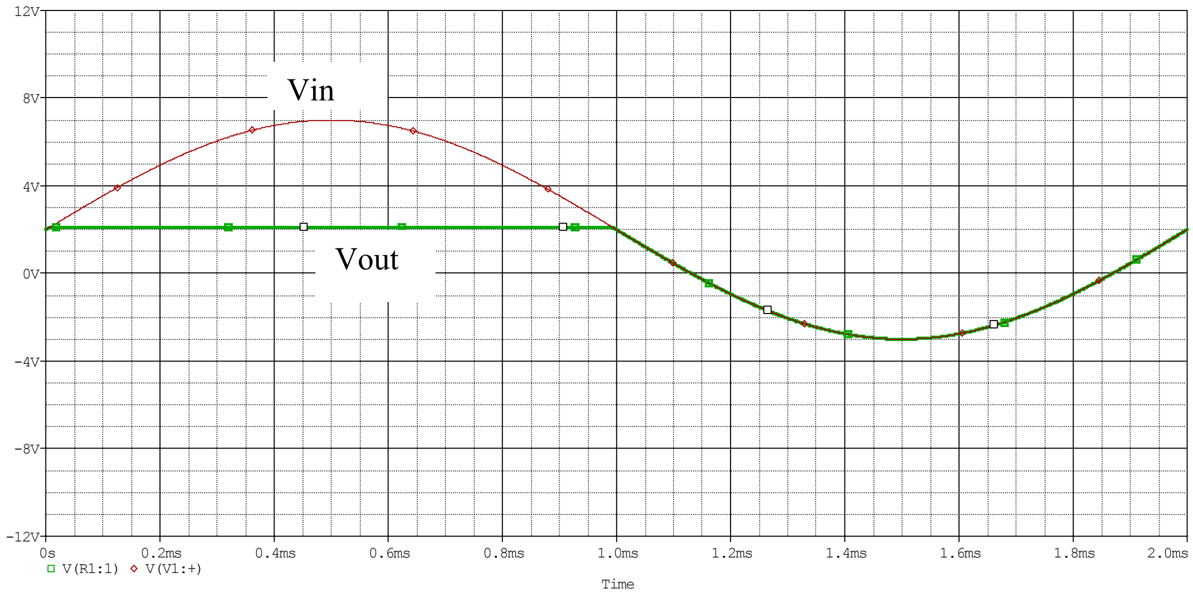


5. (3pt) What is the maximum current that will flow through resistor, R1 = 2K, when V1 has: VAMPL = 5V, VOFF = -2V, FREQ = 2kHz (part 4.)?

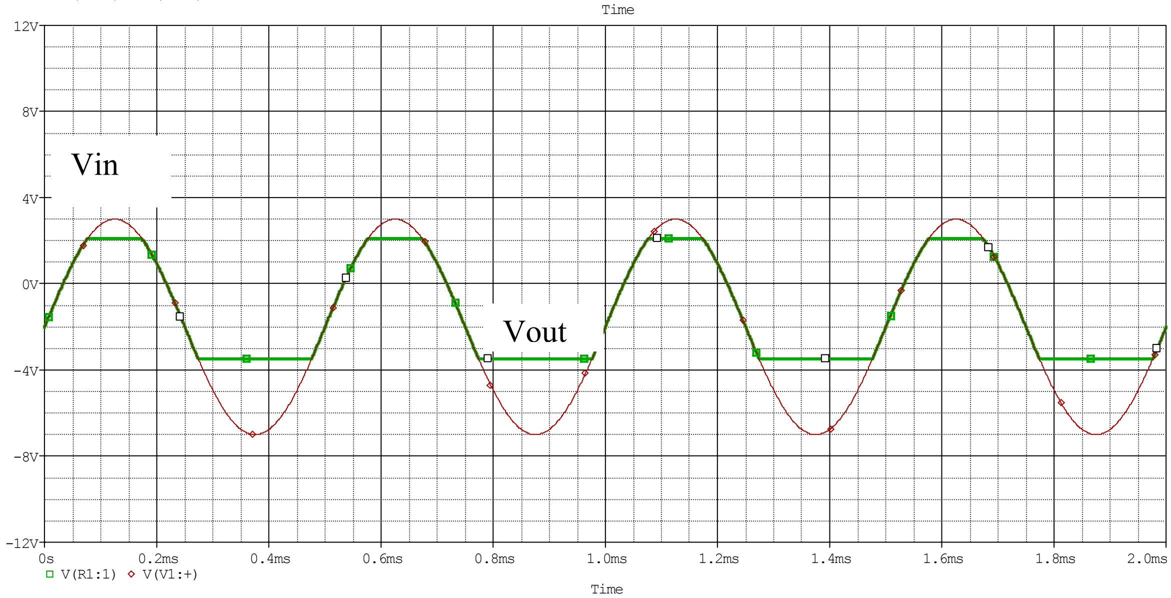
Imax = (5V – 2.1V)/1kΩ = 1.45mA



Vin
Vout
12V
8V
4V
0V
-4V
-8V
-12V
0s
0.2ms
0.4ms
0.6ms
0.8ms
1.0ms
1.2ms
1.4ms
1.6ms
1.8ms
2.0ms
V(R1:1) V(V1:+)
Time



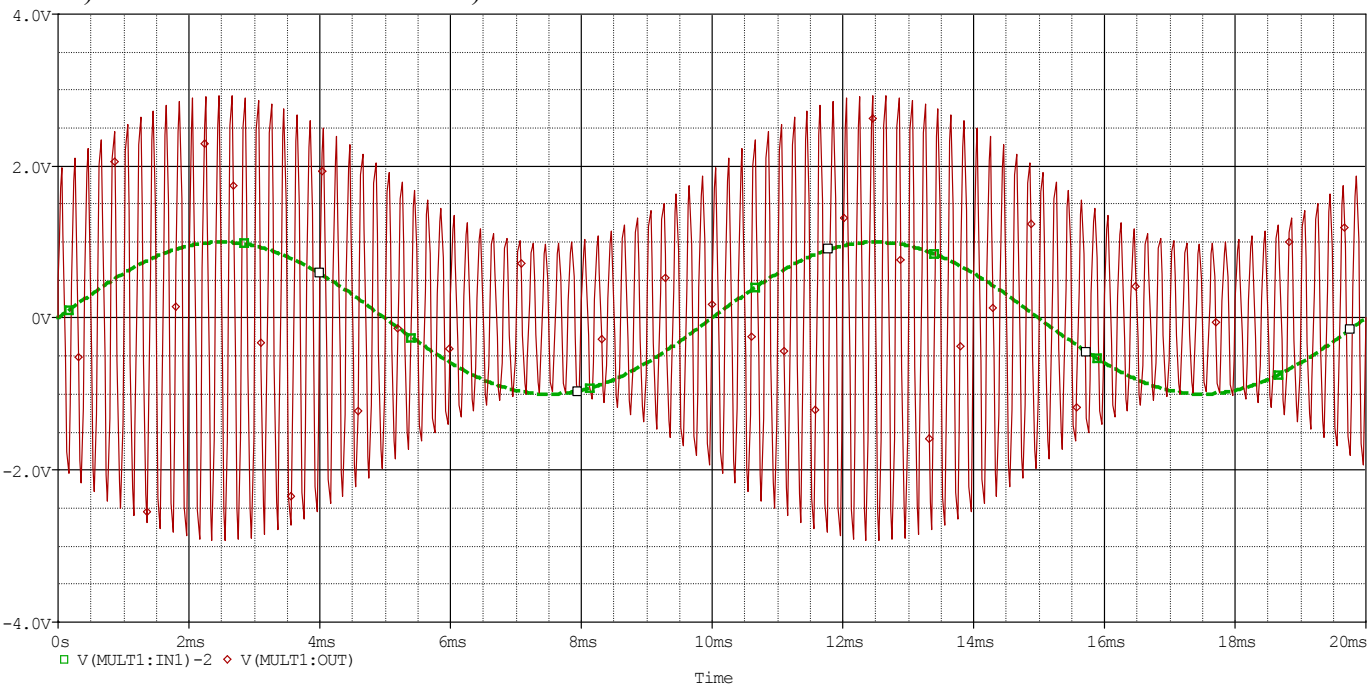
Vin
Vout
12V
8V
4V
0V
-4V
-8V
-12V
0s
0.2ms
0.4ms
0.6ms
0.8ms
1.0ms
1.2ms
1.4ms
1.6ms
1.8ms
2.0ms
V(R1:1) V(V1:+)
Time



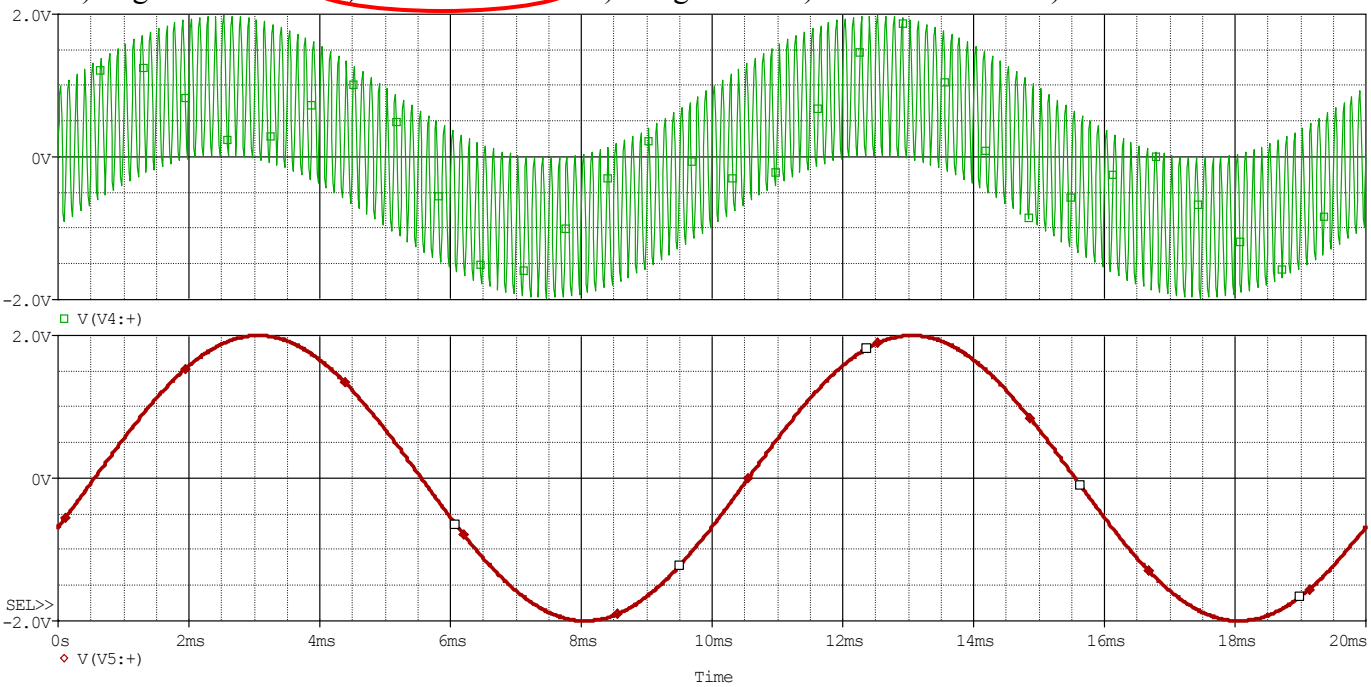
Vin
Vout
12V
8V
4V
0V
-4V
-8V
-12V
0s
0.2ms
0.4ms
0.6ms
0.8ms
1.0ms
1.2ms
1.4ms
1.6ms
1.8ms
2.0ms
V(R1:1) V(V1:+)
Time

Question V – Signal Modulation and Filtering (18 points)

1. (3pt) If the input to a block is the heavy dashed signal in the plot below and the output is the solid signal, what type of modulation is most likely being used?
a) Amplitude Modulation b) Frequency Modulation c) Pulse Position Modulation
d) Pulse Width Modulation. e) None of the above

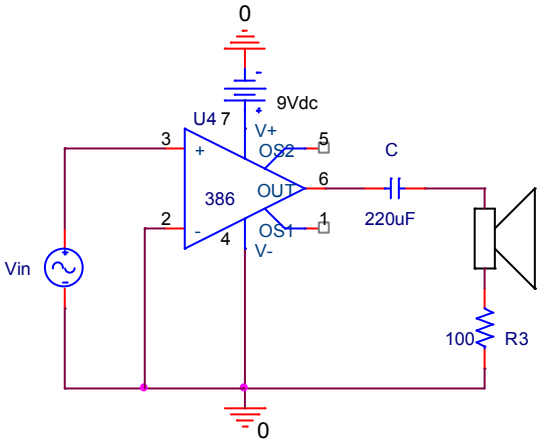


2. (3pt) If the top plot below represents the input to a circuit and the bottom the output, in addition to a possible gain stage, what type of operation does the circuit perform?
a) High Pass Filter b) Low Pass Filter c) Integration d) Differentiation e) Modulation

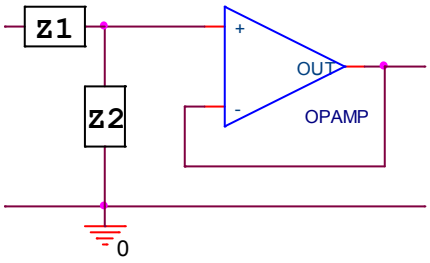


Question V – Signal Modulation and Filtering (continued)

3. (3pt) What is the main purpose of the capacitor in the audio amplifier circuit below?
a) Boost the gain of the op-amp b) Match the impedance of the speaker to the op-amp
c) Block low frequencies in the signal d) Reduce the resistance of the speaker
e) Allow the op-amp to act as a low pass filter



4. (6pt) It is decided to use the circuit below as part of the audio receiver system to pass only frequencies above 50Hz and block frequencies below 50Hz. You are to pick one capacitor and one resistor to be inserted in Z1 and Z2. There are 3 values of resistors: 5k, 50k, & 100k, and 3 values of capacitors: 64nF, 0.4µF, & 7.6µF. Find the best combination of components and show where they will be inserted in the circuit. (Op-amp power supplies are correctly wired.)



$\omega = 2\pi f = 2\pi 50 = 314 \text{rad/s}$
$\omega = 1/(RC)$ $314 = 1/(50k \times 64n) = 1/0.0032 = 313 \text{rad/s} \Rightarrow 49.7\text{Hz}$

Z1 = 64nF Capacitor
Z2 = 50k Resistor

5. (3pt) TRUE or FALSE: Swapping the resistor and capacitor around in the circuit in 4. will transform the HPF into a LPF.