ENGR-4300

Electronic Instrumentation

Quiz 4

Spring 2011

Name _____

Section ___

Question I (20 points) _____

Question II (20 points) _____

Question III (20 points) _____

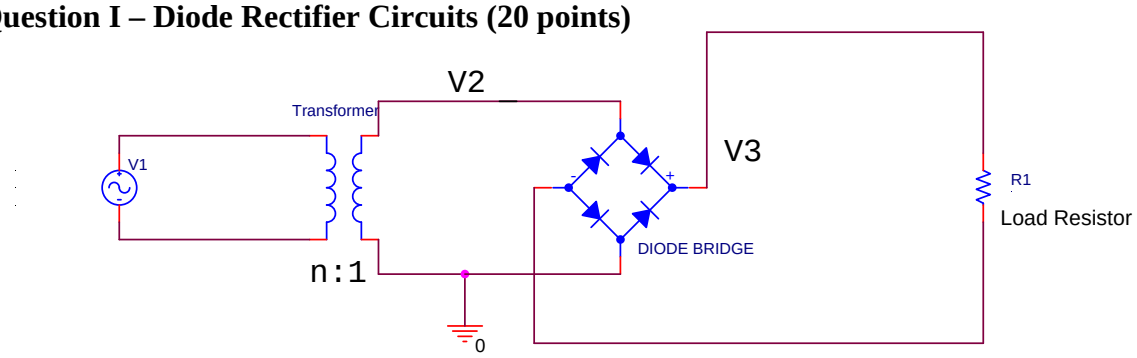
Question IV (20 points) _____

Question V (20 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 (20 points)



The diagram above shows the application of a diode bridge for performing rectification of the voltage from the output of the transformer. The sinusoidal source voltage V1 = $120V_{RMS}$ and R1 = 5kΩ.

1. (3pt) Knowing that the voltage amplitude is $\sqrt{2}$ larger than the RMS voltage, what transformer turns ratio n:1 will give as close as possible to a 6V amplitude at V2? (n should be rounded to an integer.)

n = (120 x 1.414)/6 = 28.28 => 28 n:1 = 28:1

2. (3pt) What will the actual peak voltage be on the output of the full wave bridge (across R1). Let the idealized diodes have V_{on} = 0.6V and V2 is the voltage from the turns ratio in question 1?

V = (120 x 1.414)/28 – 2x(0.6) = 4.86V

3. (3pt) Given R1 above, what is the peak current that will flow through any of the 4 diodes?

I = V/R = 4.86/5k = 0.972mA

Question I – Diode Rectifier Circuits (continued)

4. (3pt) For a 60Hz input voltage V1 a capacitor is added in parallel with R1 to reduce the ripple in the voltage across the load resistance so that the droop is less than 0.25V. Which of the following values is the minimum capacitance necessary to achieve this?

a) 1μF b) 17μF c) 33μF d) 100μF

Droop = 0.25/4.86 = 0.05

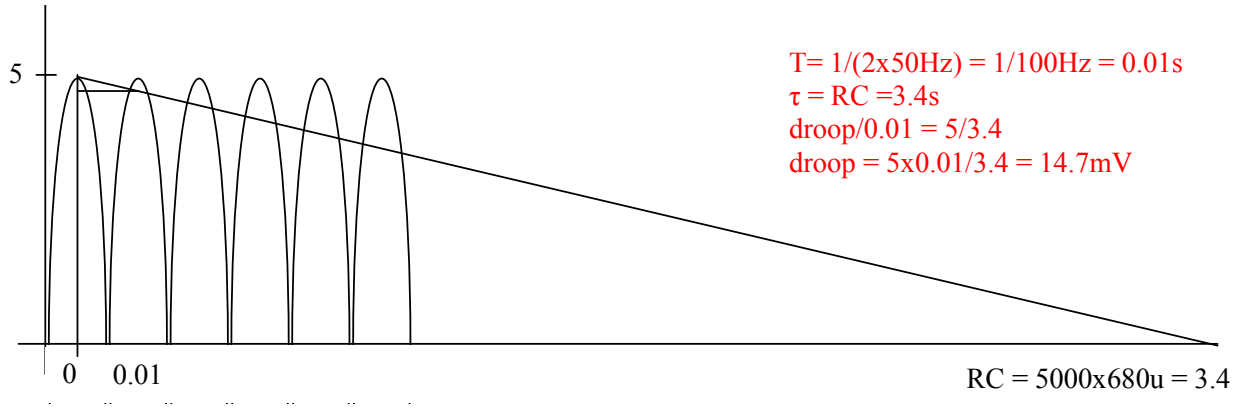
T = 1/120Hz = 8.3ms

τ = RC = 0.0083/0.05 = 0.166 C = 0.166/5000 = 33μF

5. (3pt) It is decided to use a 680μF capacitor to filter the supply voltage. What 3 digit code will be written on this capacitor to indicate its value?

687 => 68 x 10^7pF = 68 x 10^7 x 10^{-12} = 68 x 10^{-5} = 0.00068F

6. (5pt) For a quick calculation of the voltage droop with the 680μF capacitor and 5kΩ load resistance, assume a 5V amplitude 50Hz sine wave has been ideally full wave rectified (V_{on} = 0V). Use the period between adjacent peaks as the maximum droop time and assume the exponential decay can still be modeled as a straight line in this interval. With these simplifications, how much will the voltage droop from its 5V maximum value?

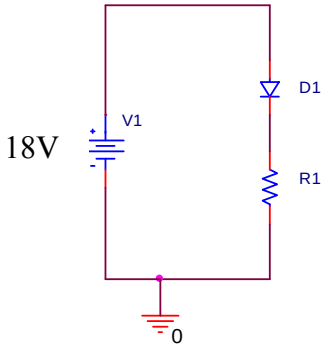


T= 1/(2x50Hz) = 1/100Hz = 0.01s
τ = RC =3.4s
droop/0.01 = 5/3.4
droop = 5x0.01/3.4 = 14.7mV

Question II - LEDs and Phototransistor Circuits (20 points)

A white LED is driven by a standard DC source. The source we have is a 18 Volt wall wart capable of producing up to 20 Watts. We need a forward bias voltage of 3.5V and a current of 50 mA.

a) (***5pt***) Using the 18 Volt supply, determine the resistance R1 necessary to achieve the desired operating conditions for the diode. Also determine the total power dissipated in the circuit.



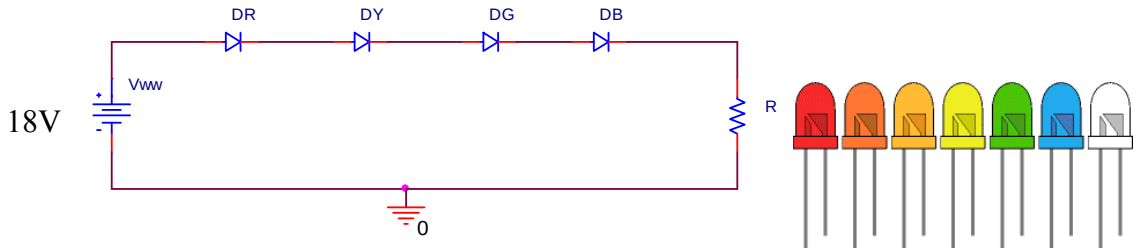
18-3.5=14.5V

14.5/50mA=290Ohms

*330 Ohms is also correct since that is the nearest available resistor value. Power = 18*50mA=900mW*

b) (***10pt***) We now want multiple LEDs like a short string of Christmas lights. For this purpose, we will use four different color LEDs: Red, Amber, Green and Blue. The four LEDs we have are found in the table below. Our Red LED is labeled Super Red in the table and all four LEDs are indicated in bold letters. **Determine the resistance** to achieve the desired operating conditions for the combination of 4 LEDs. Assume that the current is 25mA, since we have to be limited to the smallest maximum current for any of our four LEDs. Use the typical forward bias voltages from the table.

Color	Material	Wavelength (nm)	V-forward
Super Red	GaAlAs	660	1.8
Green	GaP	565	2
Red	GaAsP	645	2
Red	AlInGaP	646	2
Orange	AlInGaP	610	2
Yellow	AlInGaP	590	2
Amber	GaAsP	605	2.1
Red	GaP	700	2.1
Green	GaP	555	2.1
Green	AlInGaP	574	2.2
Blue	SiC	430	3.5
Green	InGaN	505	3.5
Blue	InGaN	470	3.5
White	InGaN		3.5
Green	InGaN	525	3.7
Green	InGaN	525	4
Blue	SiC	430	4.5



18V – 1.8-2.1-3.5-4.5=18-11.9V=6.1 6.1/25mA=244Ohms

270 Ohms is also correct since you cannot buy a 244 Ohm resistor

c) (5pts) Determine the total power dissipated in the circuit and the power dissipated in the blue LED.

Total power is 18x25mA=450mW or less than a half watt

Power in blue LED is 4.5x25mA=112.5mW

While not asked for here, the power in the resistor is 78mW so a quarter Watt resistor, like we use in class, is fine for this application.

d) (5pts?) On this quiz, you must solve problems II and III. For **one** of the other three problems, you can choose to either:

- Write 'do not grade' on it an 20 points, regardless of your actual answer, or
- Solve the problem and, if you orrect, you will receive 25 points

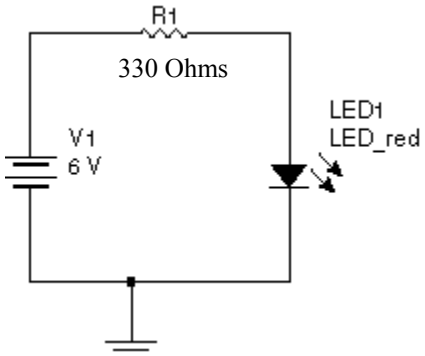
Note that you have this option fo ree problems. You must solve the remaining two problems.

Question III Multiple Choice Questions (20 points) Circle the correct answer. (2 points for each question).

a. The dc current through each forward-biased diode in a full wave bridge rectifier equals:
   a. The load current
   b. Half the dc load current
   c. Twice the dc load current
   d. One-fourth the dc load current

b. When matching polarity connections have been made and the voltage difference is above 0.7 V, the diode is considered to be:
   a. Not working
   b. Forward biased
   c. Reverse biased
   d. An open switch

c. What is the current through the LED?



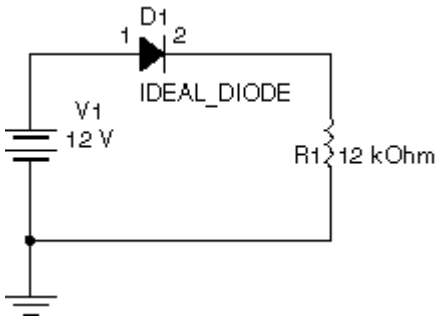
   a. 0 mA
   b. 23 mA
   c. 18 mA
   d. 13 mA

d. A filtered full-wave rectifier voltage has a smaller ripple than does a half-wave rectifier voltage for the same load resistance and capacitor values because:
   a. There is a shorter time between peaks
   b. There is a longer time between peaks
   c. The larger the ripple, the better the filtering action
   d. None of the above

e. Testing a good diode with an ohmmeter should indicate
   a. High resistance when forward or reverse biased
   b. Low resistance when forward or reverse biased
   c. High resistance when reverse biased and low resistance when forward biased
   d. High resistance when forward biased and low resistance when reverse biased

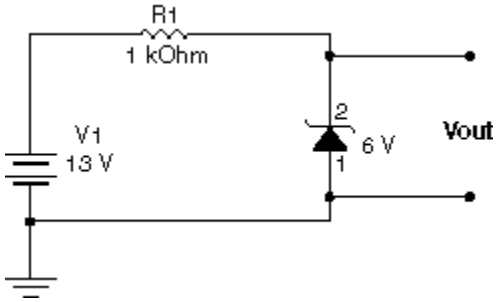
f. The peak inverse voltage across a nonconducting diode in a bridge rectifier equals approximately:
   a. Half the peak secondary (output) voltage
   b. Twice the peak secondary (output) voltage
   c. The peak value of the secondary (output) voltage
   d. Four times the peak value of the secondary (output) voltage

g. What is the current through the diode?



   a. 1 mA
   b. 0.975 mA
   c. 0.942 mA
   d. 0.0 mA

h. What is the current through the zener diode?

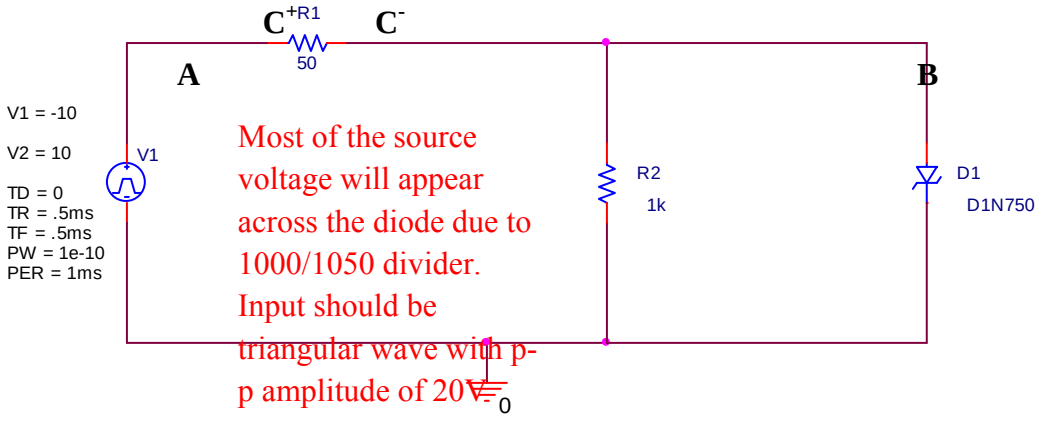


   a. 0.0 mA
   b. 7 mA
   c. 8.3 mA
   d. 13 mA

i. When a diode is forward biased, the voltage across it
   a. Is directly proportional to the current
   b. Is inversely proportional to the current
   c. Is directly proportional to the source voltage
   d. Remains approximately the same

j. When checking a diode, low resistance readings both ways indicate the diode is:
   a. Open
   b. Satisfactory
   c. Faulty
   d. Not the problem

Question IV – Zener Diode Circuits (20 points)

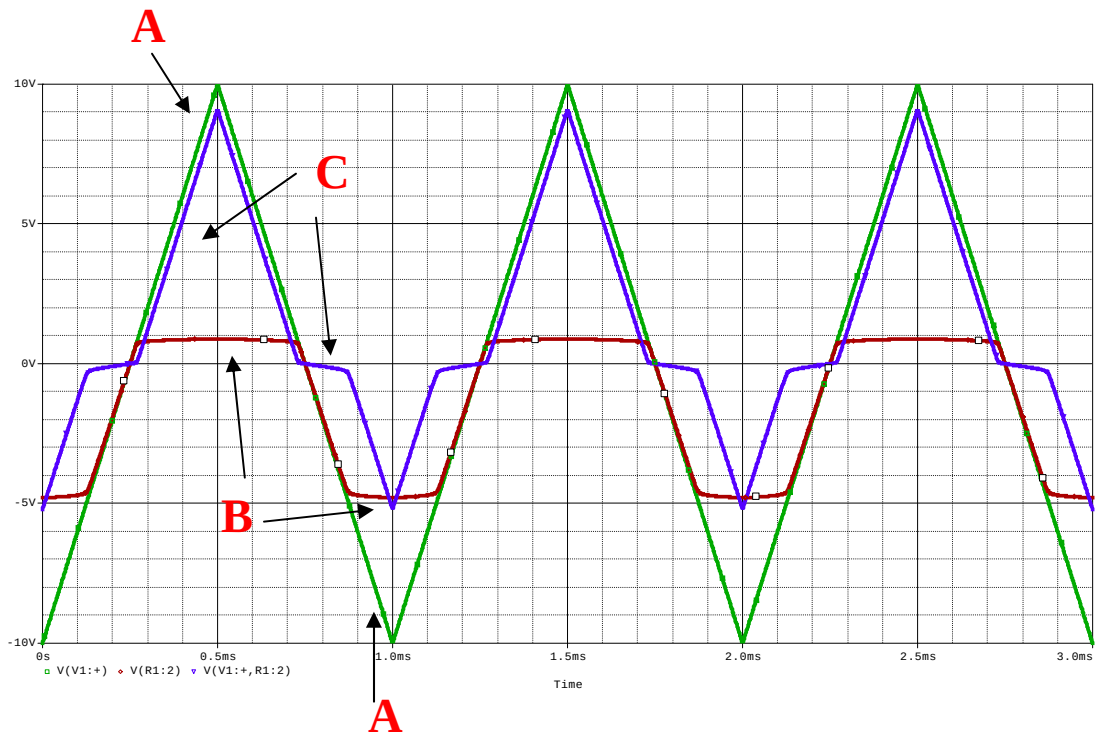


The circuit above is a Zener diode voltage regulator. A Zener diode is used to regulate the voltage across the load resistor R2 in the circuit. Shown below are two figures, one of which shows the correct voltages for this configuration.

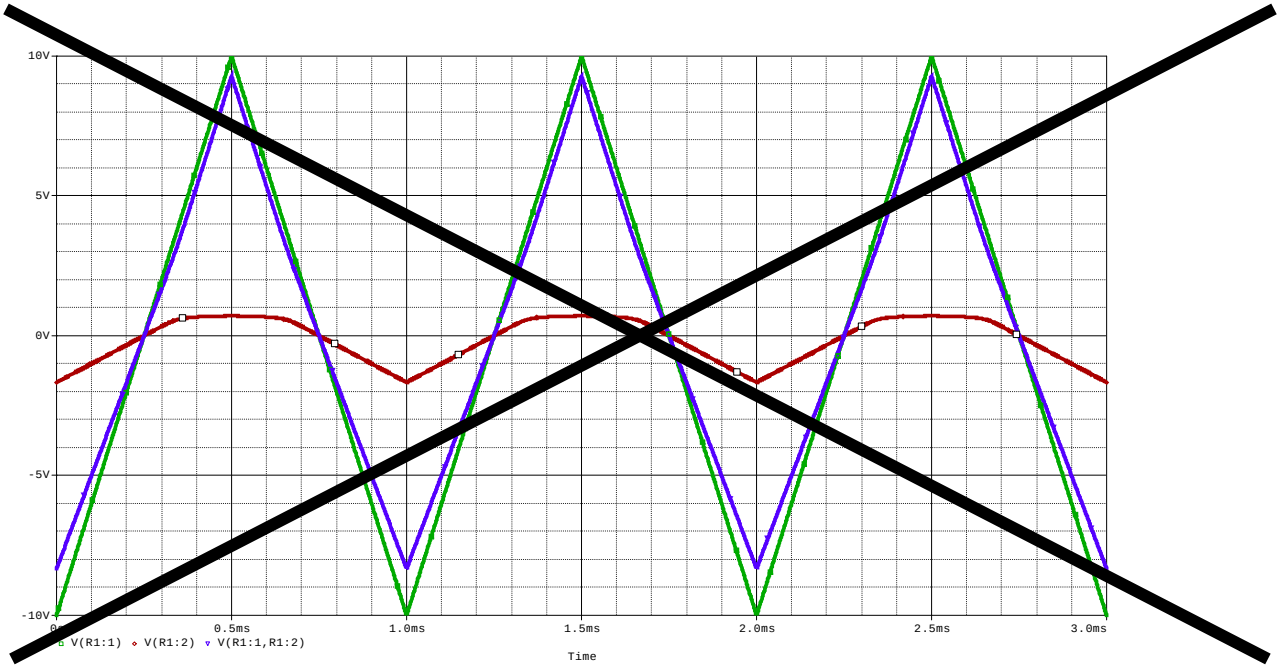
a) (5pts) Identify which of the two figures is correct by crossing out the one that is incorrect. Explain your answer.

Most of 10V is enough to turn on the Zener.

b) (5pts) On the correct figure, label which plot corresponds to the voltages at points A and B and across resistor R1 (C^+ to C^-)



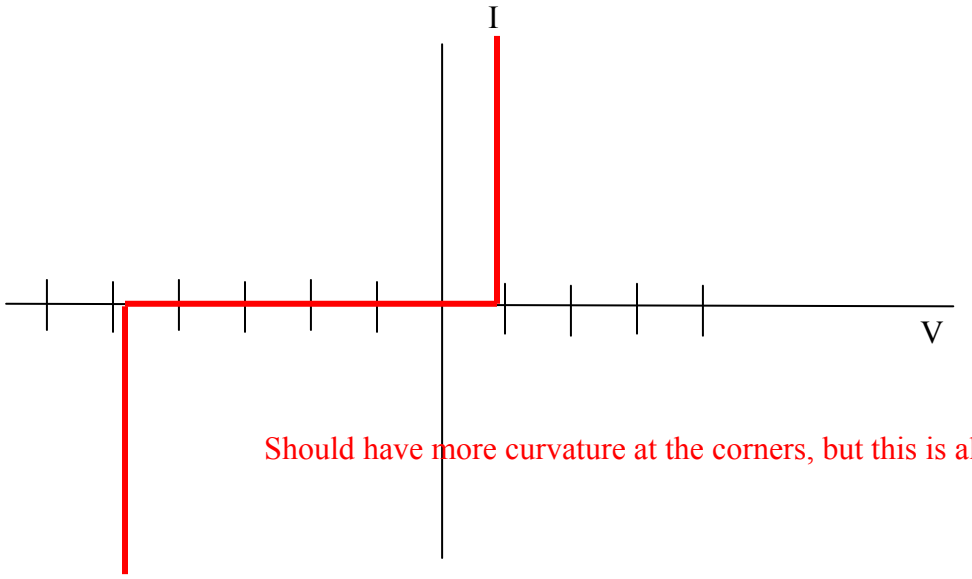
Zener clamps voltage at about 0.7V forward and about 5V reverse (Zener)



c) (6pts) From the given information, determine the Zener voltage for this diode V_Z and the forward bias voltage necessary to turn the diode on in the forward direction. Exact answers are not required.

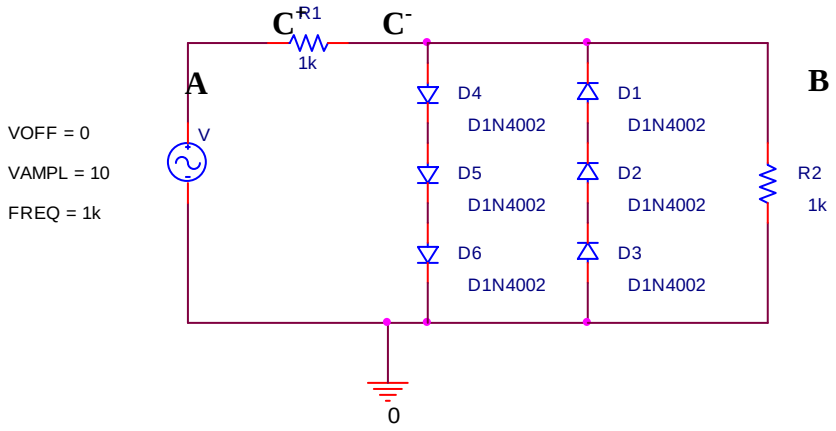
V_Z is a little less than 5V, say about 4.7V, $V_{forward}$ is a little less than 1V, say about 0.8V with a range of answers accepted. It is not necessary to be able to read the graphs precisely but the answers should be reasonable.

d) (4pts) Sketch the V-I plot for this diode. Your sketch does not have to be perfect, but it should show the main characteristics of the diode.



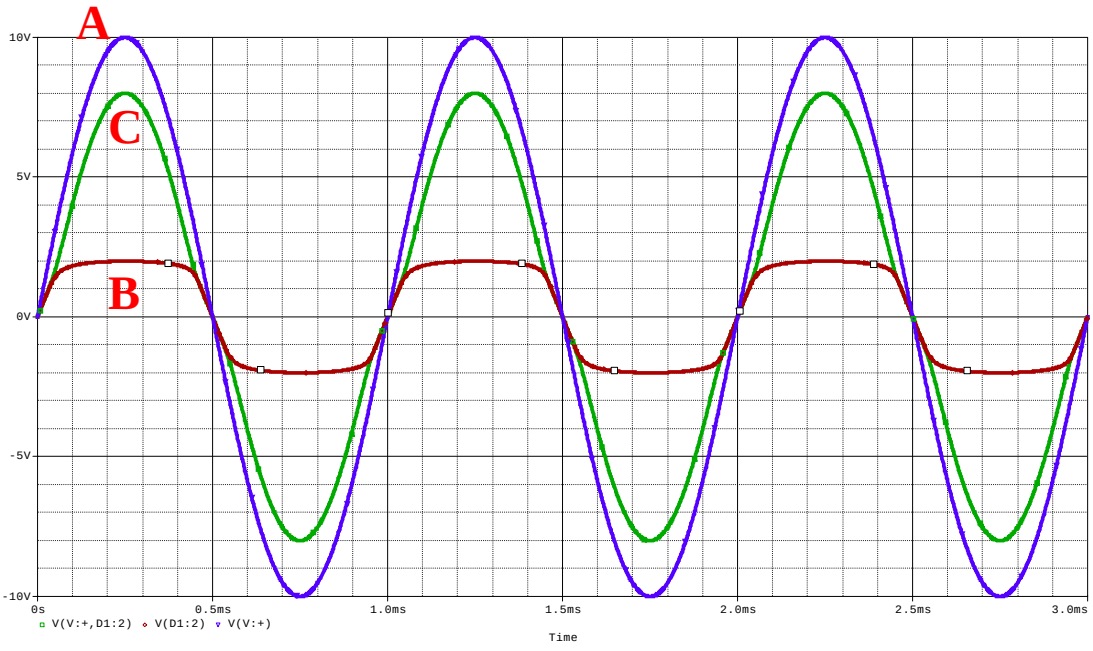
Should have more curvature at the corners, but this is also acceptable.

Question V - Diode Limiter Circuits (20 points)



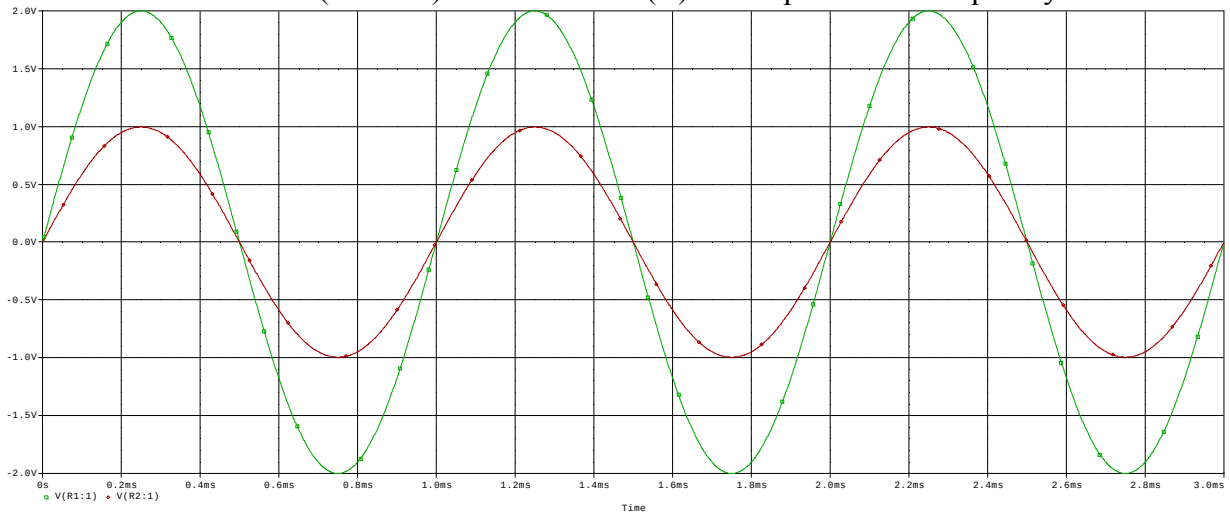
Six 1N4002 diodes are used to protect a load (in this case R2) from having too large a voltage across it. The 4002 diode has somewhat different properties than the 4148 diode we have studied in class.

a) (9pts) This configuration is tested with the sinusoidal voltage source shown in the circuit above. The voltages measured are shown below. Label which plot is the voltage at pt A, at pt B and across resistor R1 (C^+ to C^-). Explain your answer.



A is 10V sinusoid at the input, B cannot be larger than the forward bias of three diodes which is about 2V, C is what is left.

b) (6 pts) The source voltage amplitude is changed to 2V. Sketch the resulting voltage across resistor R1 (C^+ to C^-) and at the load (B) on the plot below. Explain your answer.



At 2V, the input voltage is not sufficient to turn on the diodes so they remain open and out of the circuit. All that remains is a voltage divider with two 1k resistors, so the voltage observed is a sinusoid at half the input.

c) (5pts) Using the given information, determine the forward voltage necessary to turn the 1N4002 diode on. Explain your answer.

3 diodes at about 2V means about 0.67V. A good range for the answer would be

0.6V < 0.67V < 0.7V or the usual range for simple diodes.