ENGR-4300
Spring 2009
Test 4

Name ________SOLUTION________

Section 1(MR 8:00) 2(TF 2:00) 3(MR 6:00)
(circle one)

Question I (20 points) ___________

Question II (20 points) ___________

Question III (15 points) ___________

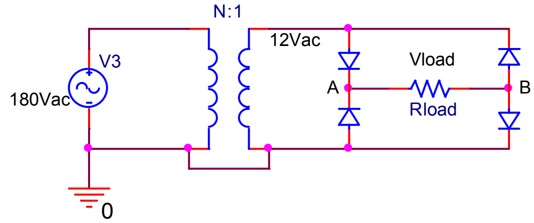
Question IV (25 points) ___________

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)



1. Designing a low-voltage DC power source from a 180Vpeak AC supply, requires a transformer and rectifier bridge.

a) (*3pt*) What should the transformer turns ratio N:1 be to output 12Vpeak on the secondary side from the 180Vpeak on the primary?

N2/N1 = V2/V1   N = N1 = V1 x N2/V2 = 180 x 1/12 = 15

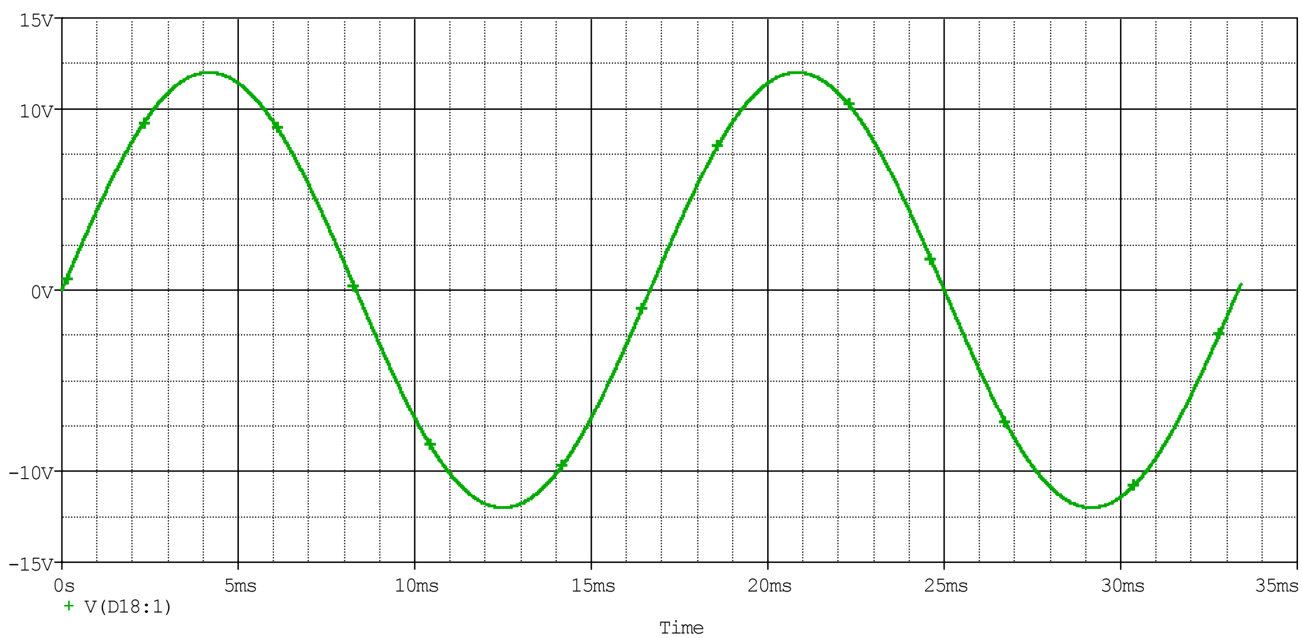
b) (*3pt*) Given the rectifier bridge circuit with 4 diodes (0.6V turn-on), what will be the peak voltage Vload across the load resistor Rload?

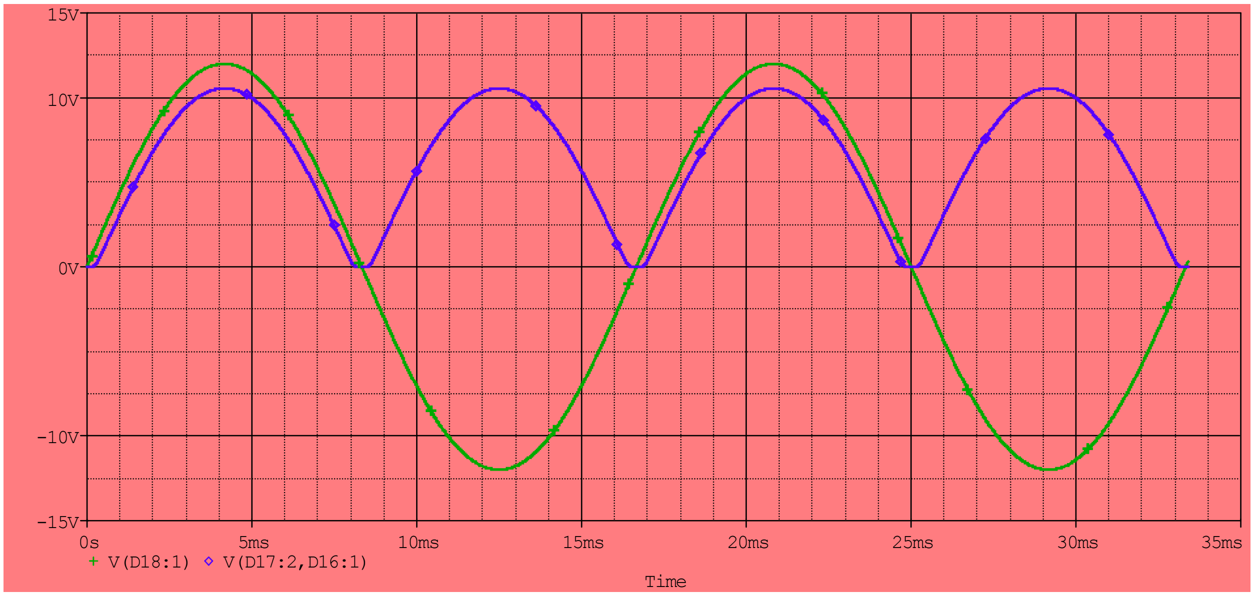
Vload = 12Vpeak – 0.6V – 0.6V = 10.8V

c) (*1pt*) Which side, **A** or **B**, of Rload is the positive (high) voltage of Vload?

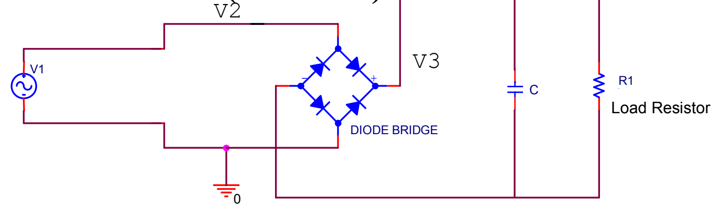
A

d) (*4pt*) With 12Vac applied to the rectifier bridge circuit shown on the plot below, sketch Vload, the voltage across Rload.

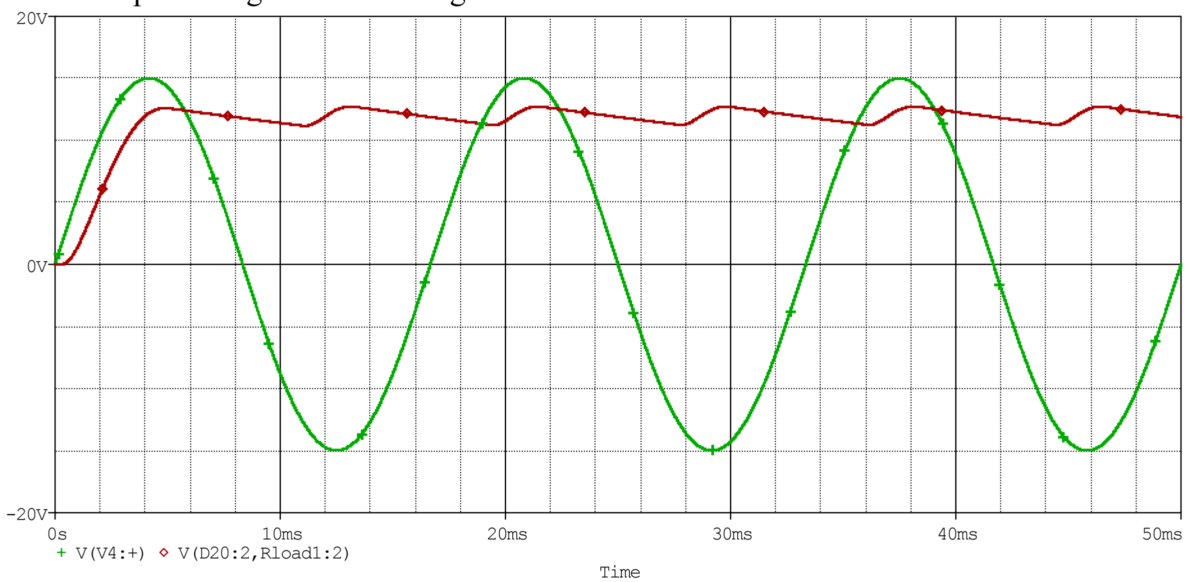



15V
10V
0V
-10V
-15V
0s
5ms
10ms
15ms
20ms
25ms
30ms
35ms
V(D18:1)
V(D17:2,D16:1)
Time

Question I – Diode Rectifier Circuits (continued)

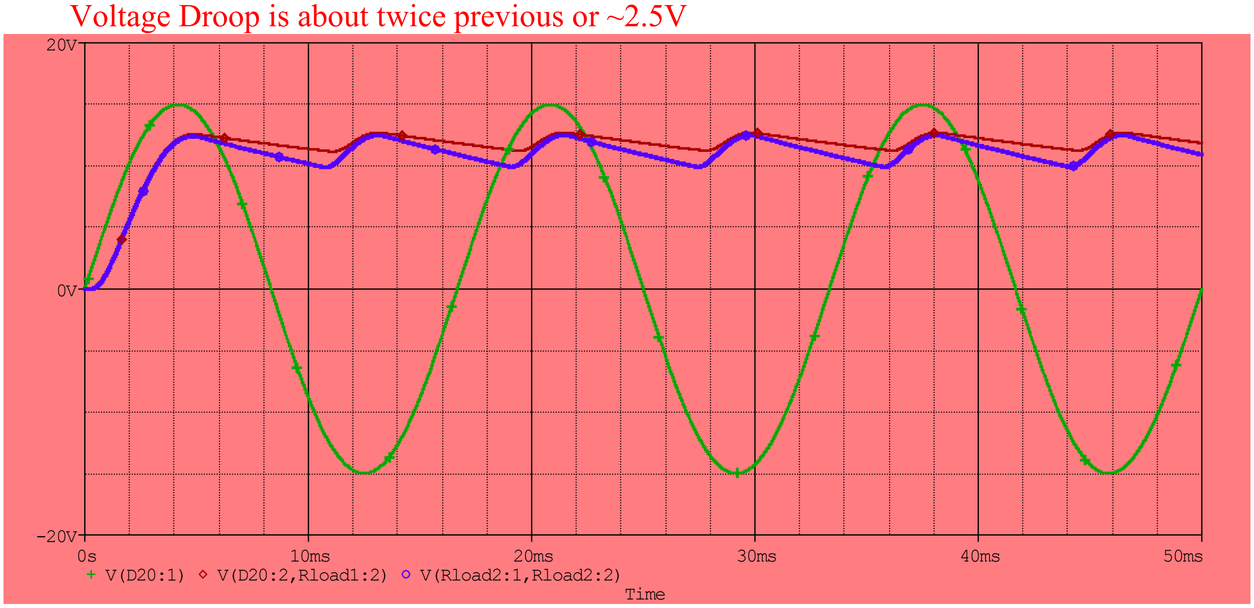


2. For the following full-wave rectifier above, with Rload = 100Ω and C = 500μF, the plot below shows the input voltage and the voltage across the load.



a) (*3pt*) On the plot, show how the voltage across the load would change if Rload is reduced to 50Ω.

Voltage Droop is about twice previous or ~2.5V

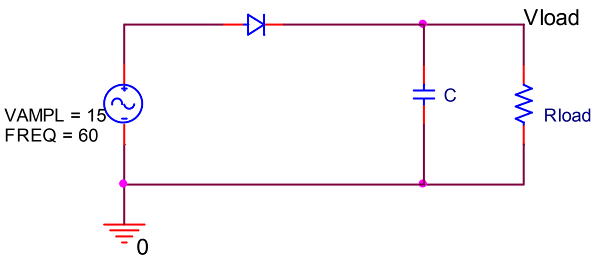


b) (*2pt*) What new value for C would restore the voltage waveform back to its original form when Rload was 100Ω?

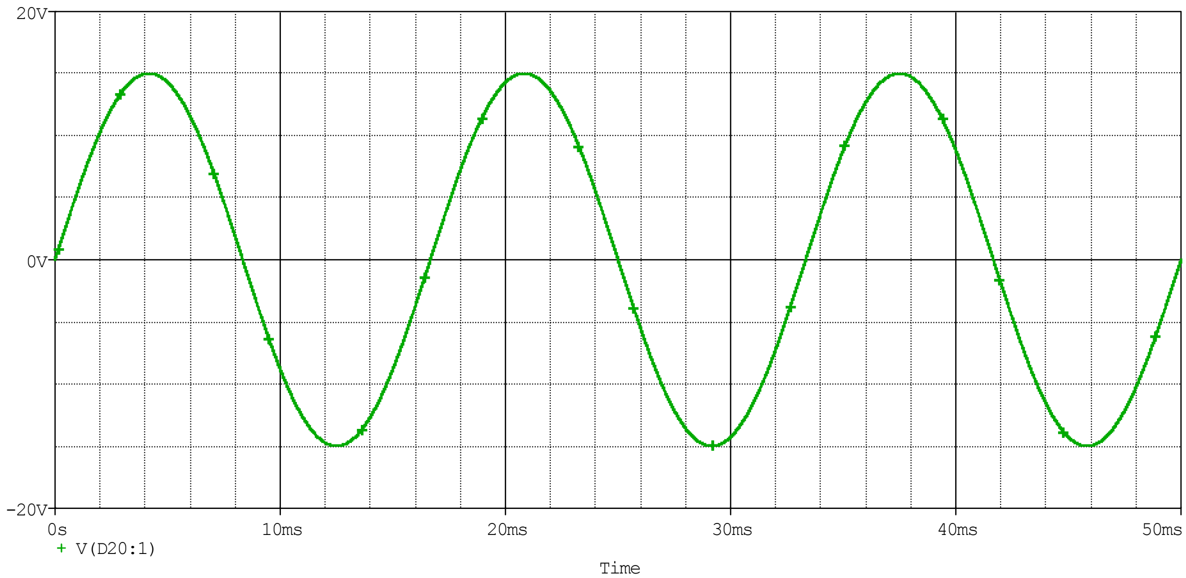
RC = R'C'

100 x 500μ = 50 x C'   C' = (100/50)500μ = 1000μF

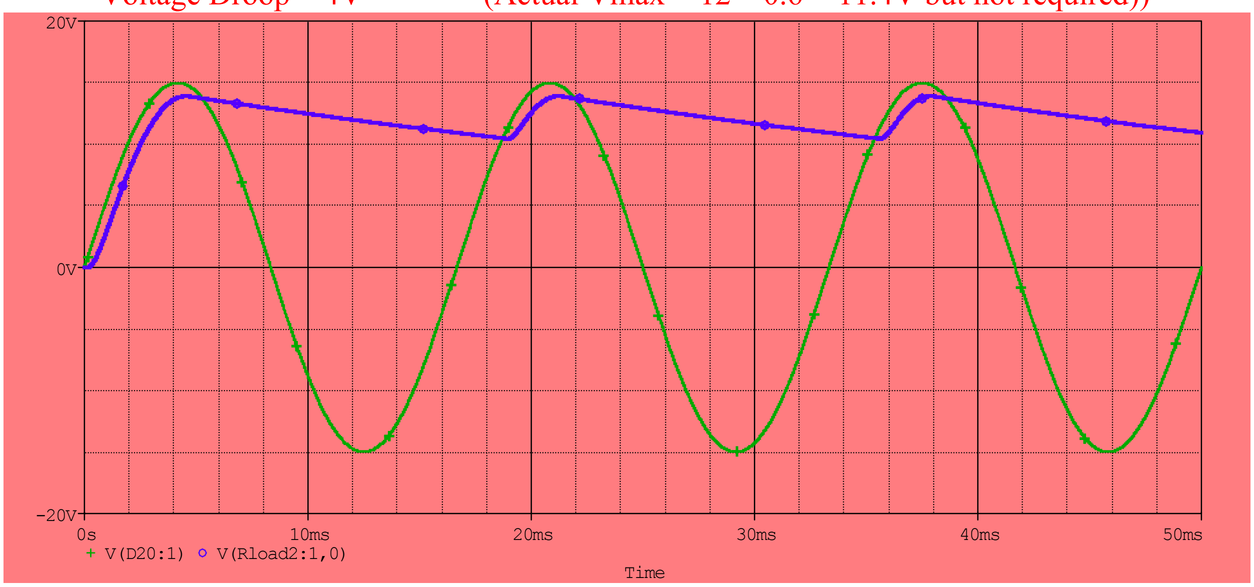
Question I – Diode Rectifier Circuits (continued)



c) (*4pt*) For an essentially equivalent half-wave rectifier circuit replacing the full-wave above, with Rload = 100 and C = 500μF as in the circuit in 1, sketch the voltage across Rload on the 15V input voltage plotted below.

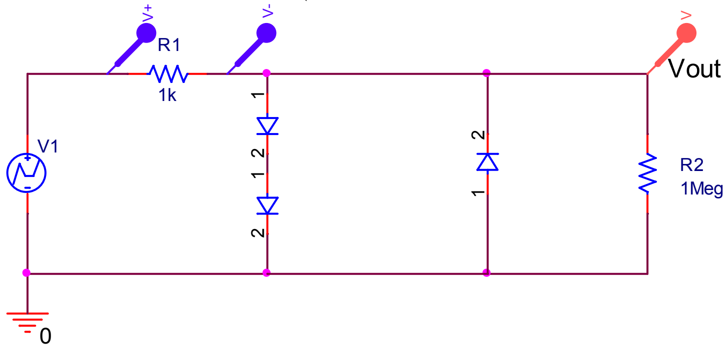


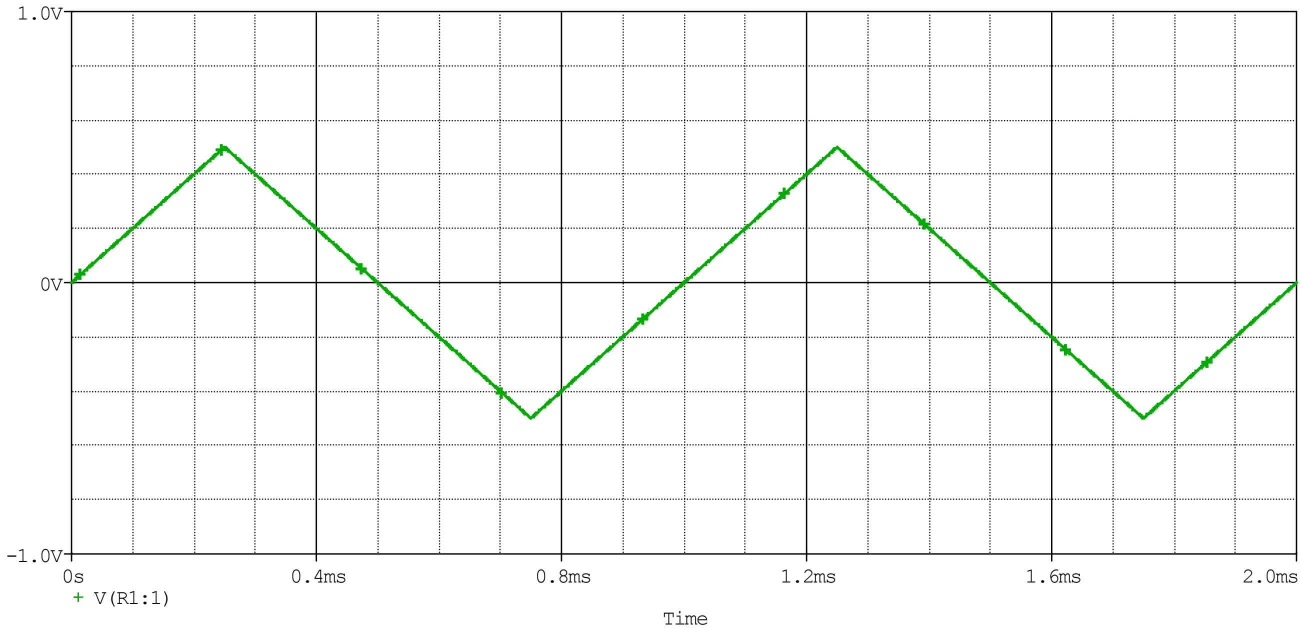
Voltage Droop ~ 4V (Actual Vmax = 12 – 0.6 = 11.4V but not required))



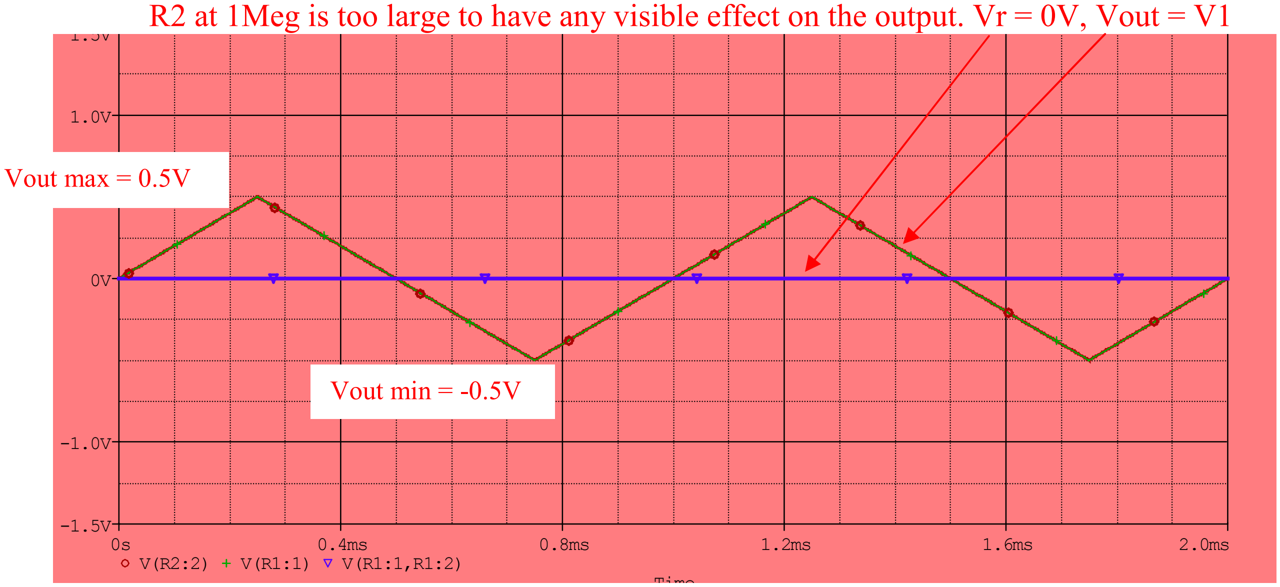
Question II – Diode Limiter Circuits (20 points)

1. (***6pt***) Draw and labelVout and Vr (the voltage across R1) on the plot below showing V1. The diodes turn on at 0.5V. (***Label the maximum and minimum of the output.***)



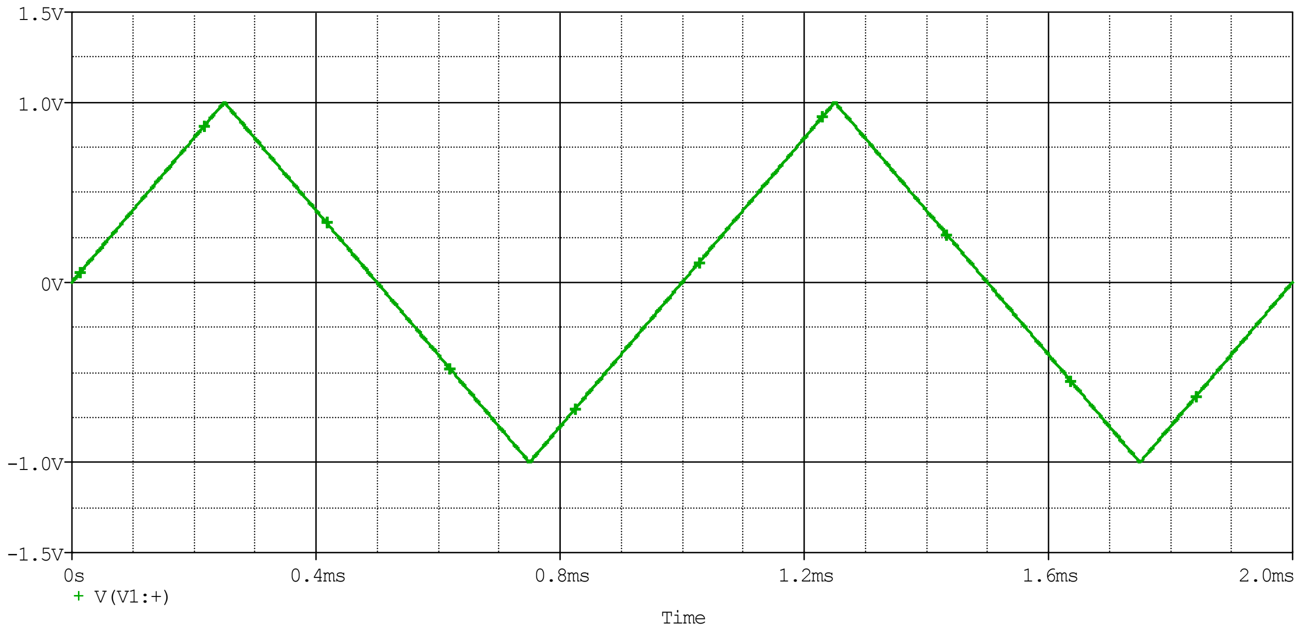


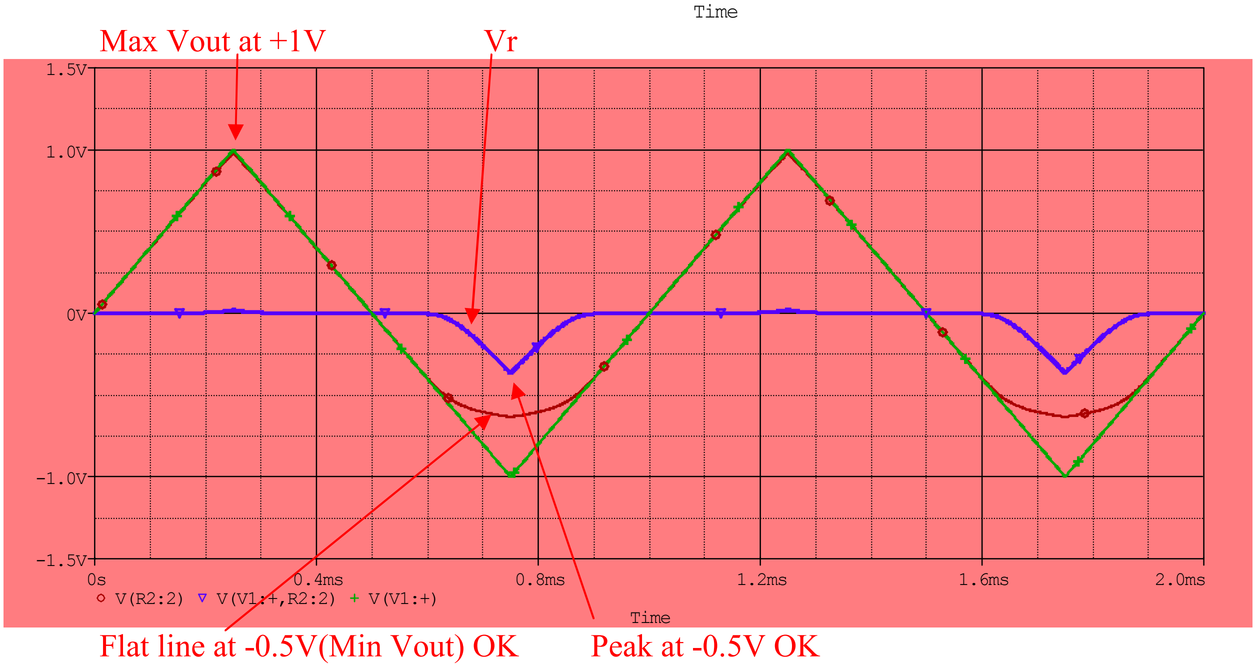
R2 at 1Meg is too large to have any visible effect on the output. Vr = 0V, Vout = V1



Question II – Diode Limiter Circuits (continued)

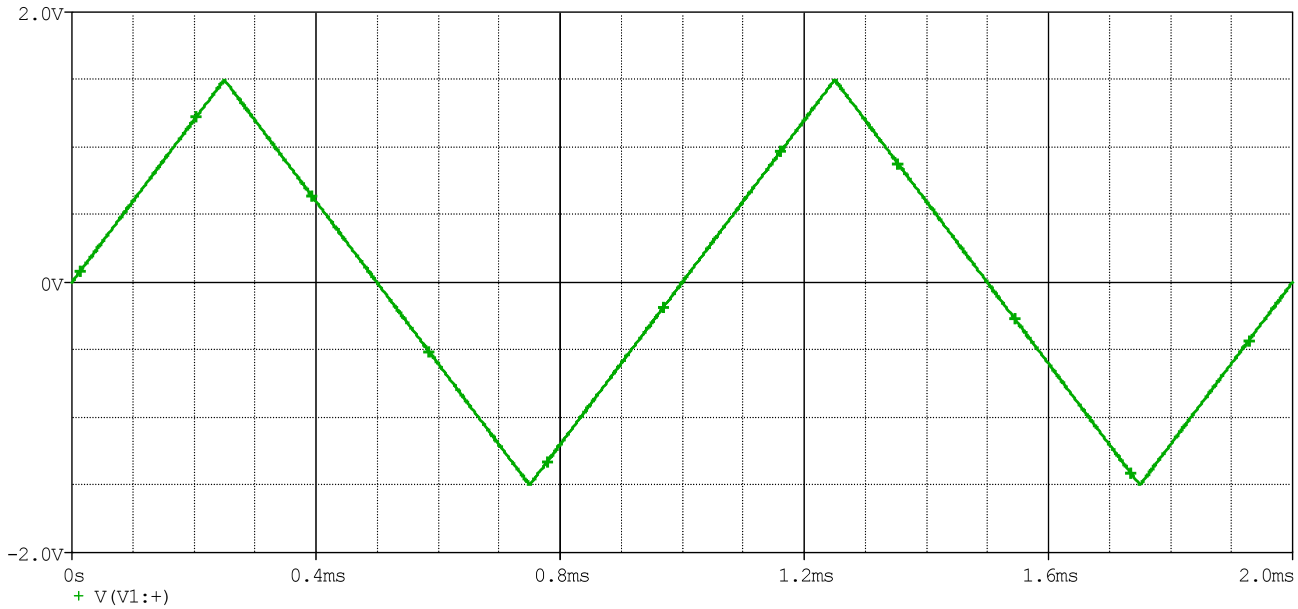
2. (*6pt*) Draw Vout and Vr on the plot below with V1 increased to $2V_{p\text{-}p}$. (***Label the maximum and minimum of the output.***)



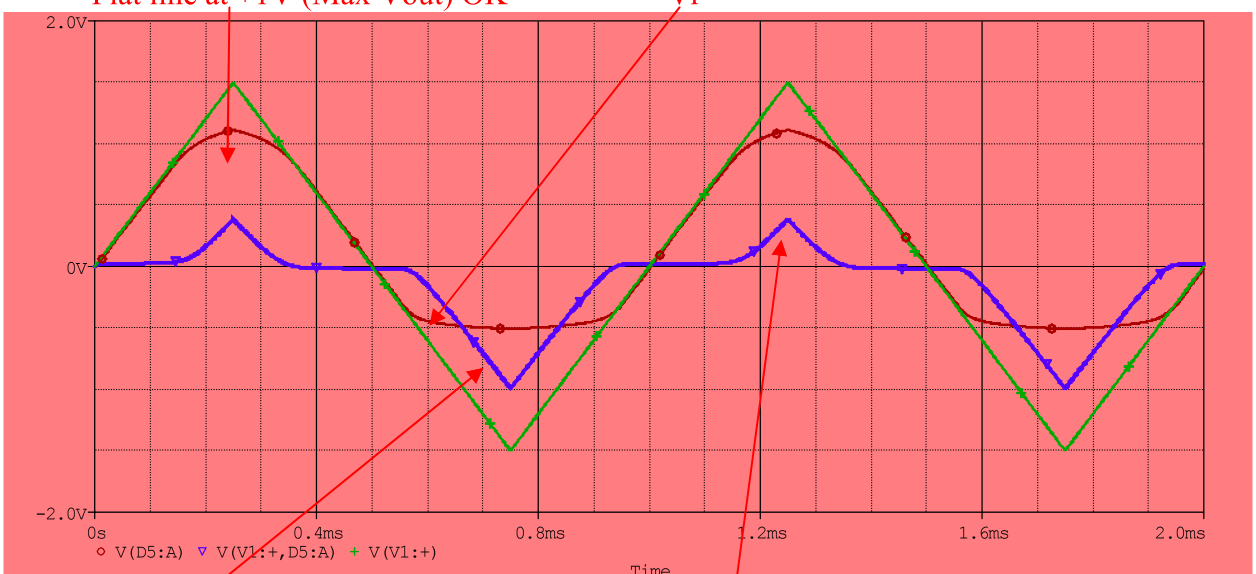


Question II – Diode Limiter Circuits (continued)

3. (*6pt*) Draw Vout and Vr on the plot below with V1 increased to $3V_{p\text{-}p}$. (***Label the maximum and minimum of the output.***)



Flat line at +1V (Max Vout) OK Vr

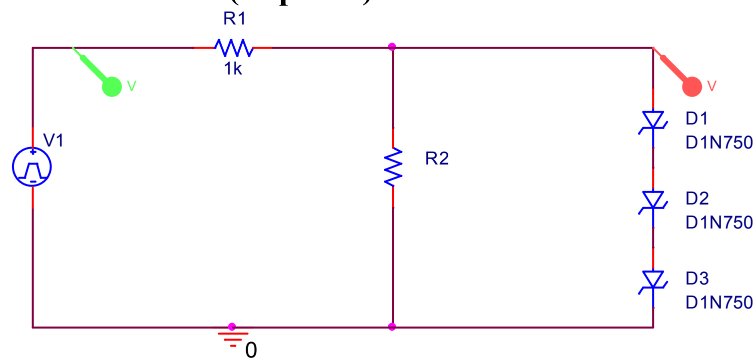


Flat line at -0.5V(Min Vout) OK Peak at +0.5V OK

4. (*2pt*) TRUE or FALSE: With a diode that turns on at 0.7V and one that turns on at 0.6V, it is possible to build a limiter circuit that turns on at 0.1V by wiring them in series, but switching the 0.6V diode's connections around.

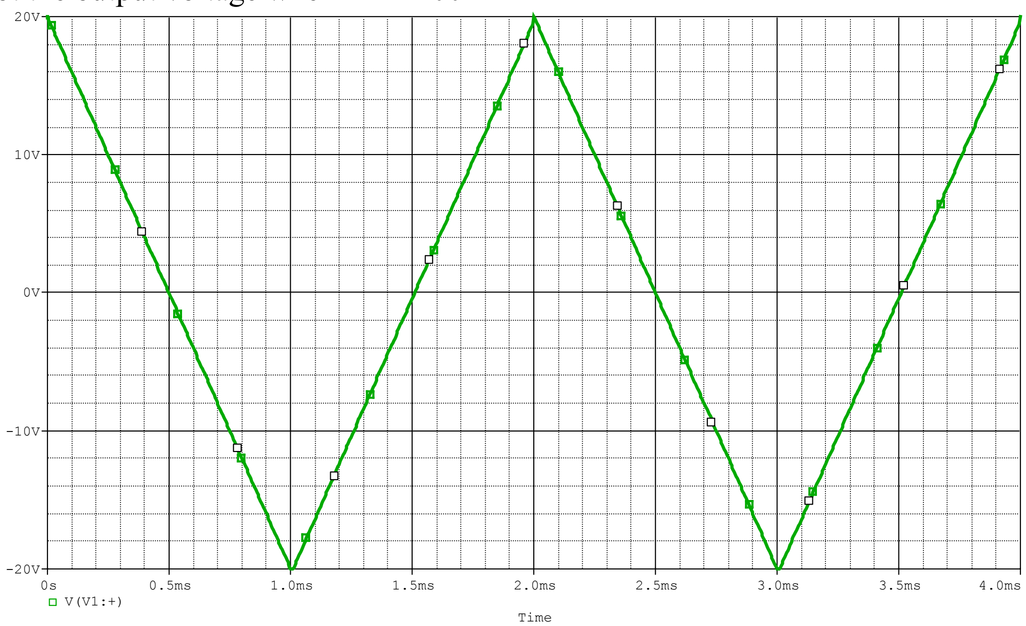
FALSE, no current will flow through the series combination since one diode will always be off.

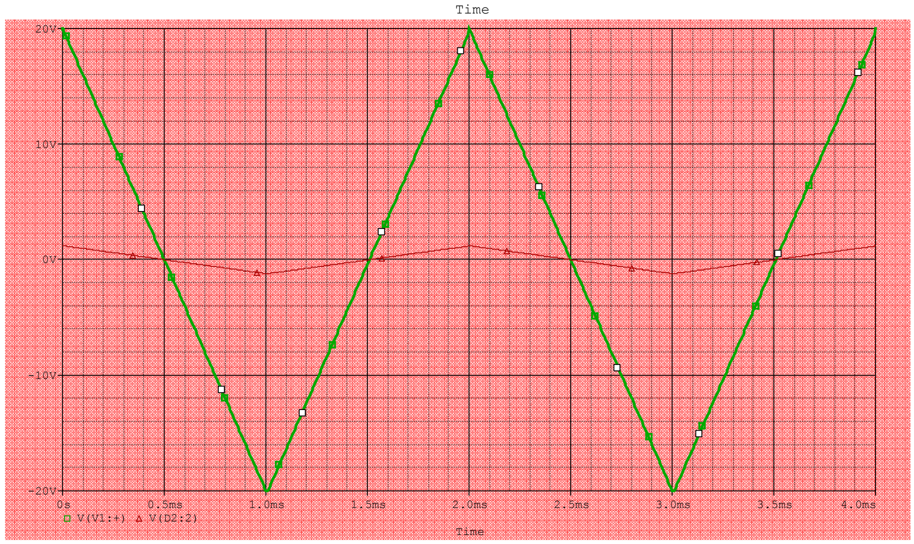
Question III – Zener Diode Circuits (15 points)



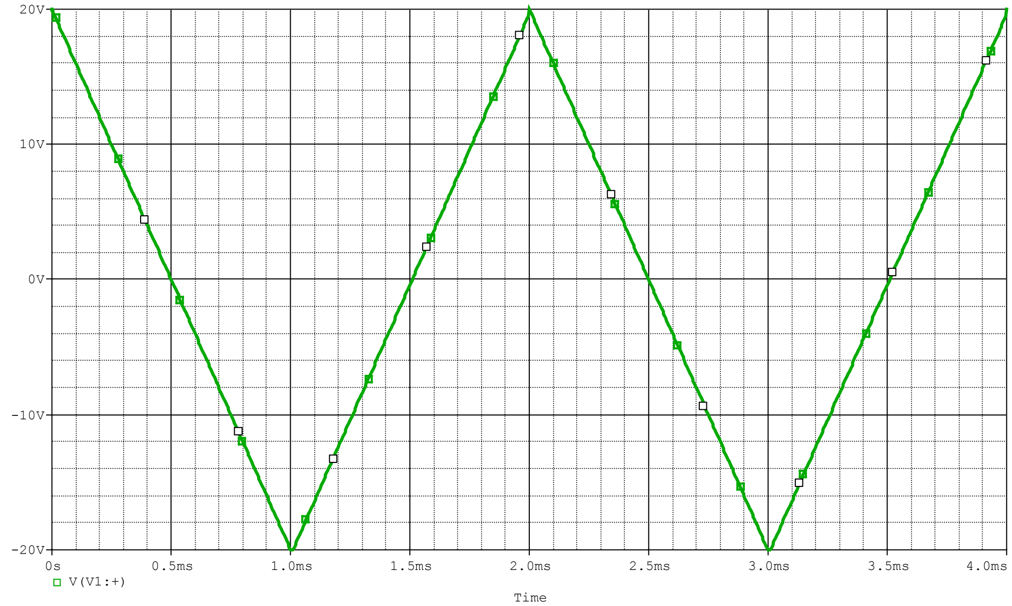
The circuit above is a zener diode voltage regulator. Three Zener diodes are used to regulate the voltage across the load resistor R2 in the circuit below. Three different values of R2 are tried (100Ω, 1kΩ, and 10kΩ) Draw the voltage on the output probe above D1. ***Calculate your answers.***

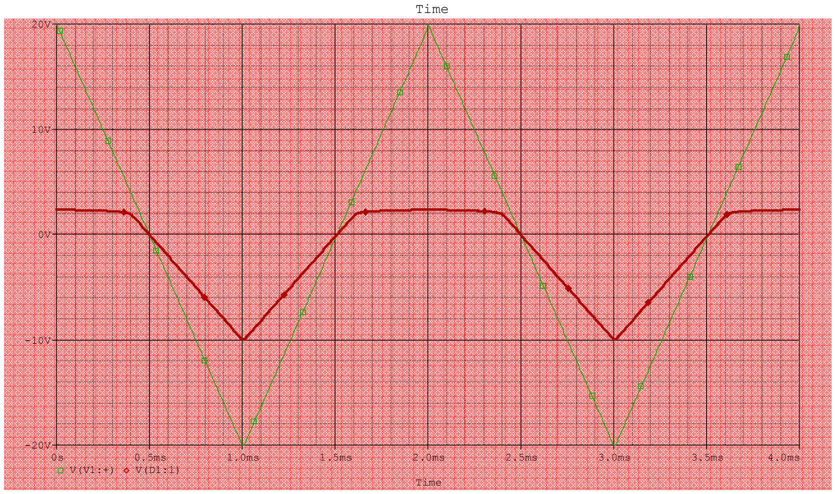
1. (***3pt***) Plot the output voltage when R2 = 100Ω



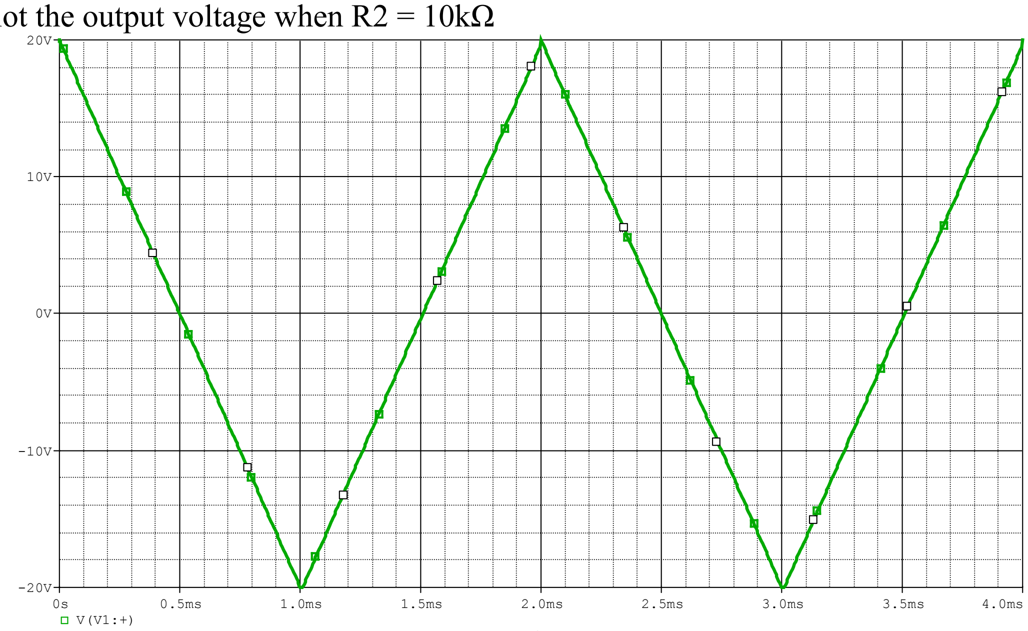


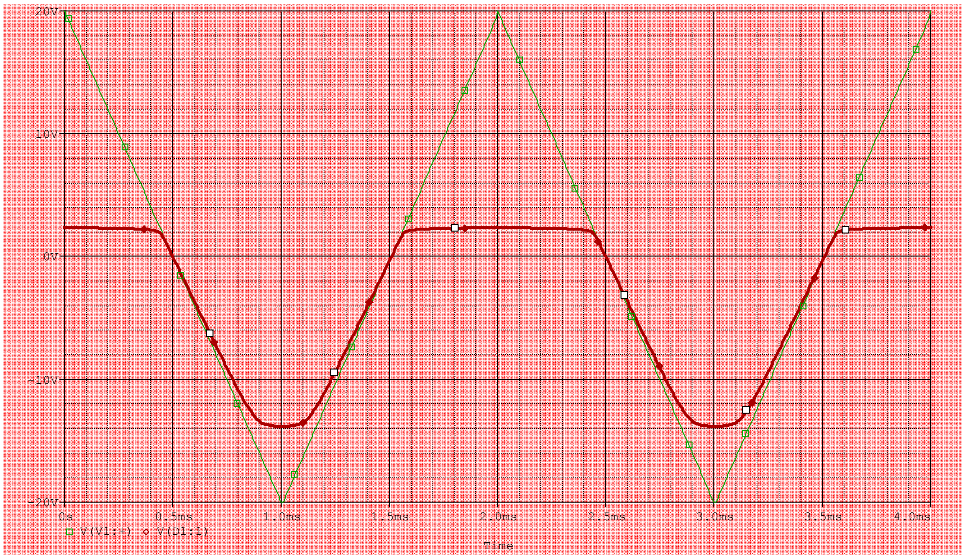
2. (***3pt***) Plot the output voltage when R2 = 1kΩ





3. (***3pt***) Plot the output voltage when R2 = 10kΩ





4. (***3pt***) What is the voltage across R2 when R2 is 10kΩ and the input voltage is 5V?

The voltage divider makes the voltage 4.5 V which is above the limit at 2.1 V. Therefore the voltage is held at 2.1V.

5. (***2pt***) What is the current through R2 when R2 is 10K and the input voltage is -17V?

Voltage divider voltage is -15.4 which is above -14.1 so it is held at -14.1V
i = Vload/Rload = -14.1/10kΩ = -1.41 mA

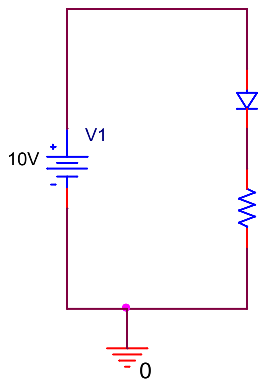
6. (***1pt***) Which of the 4 Electronic Instrumentation projects could have benefitted most from a voltage regulated circuit? (***A major component was highly sensitive to voltage in this project***)

The Accelerometer modules in Project 2 would have been better protected by the circuit above, which would prevent larger voltages than the module can withstand from being applied to it.

Question IV - LEDs and Phototransistor Circuits (25 points)

A high brightness LED is driven by a standard DC source. The source we have available is a 10 Volt wall wart capable of producing up to 5 Watts. We need a forward bias voltage of 4V and a current of 50 mA.

1. (***5pt***) Using the 10 Volt supply, determine the resistance R1 necessary to achieve the desired operation conditions for the diode. Also determine the total power dissipated in the circuit.



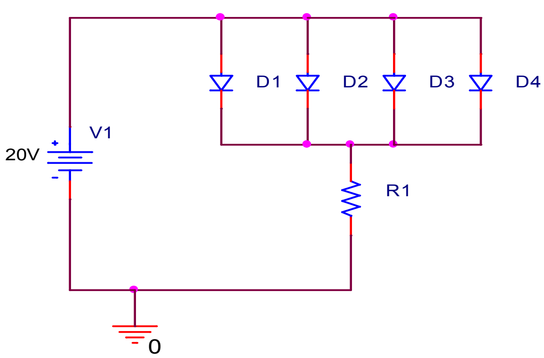
$$R_1 = \frac{10-4}{.05} = 120\Omega$$

$$P_{diode} = 4 \times 0.05 = 0.2W$$

$$P_{res} = 6 \times 0.05 = 0.3W$$

$$P_{total} = 0.2W + 0.3W = 0.5W \quad (= 10\text{V} \times 50\text{mA})$$

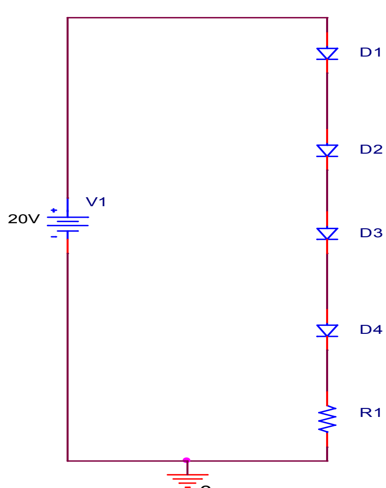
2. (***10pt***) We now want multiple LEDs like a short string of Christmas lights. ***Find R1 for both circuits below.*** Choose the circuit below that will operate with a 20 Volt wall wart capable of producing 4.5 Watts. The LEDs need 4V and 50 mA of current each to operate. ***You may also choose neither or both. Explain with calculations of current, voltage, and power limits in your answer.***



$$R_1 = \frac{20-4}{0.05 \times 4} = 80\Omega$$

Meets voltage requirement only takes 4V to light them
Meets current requirement 4.5Watts/20V=225mA total in circuit diodes use 200mA
Total Power requirements $P_{diode} = 4 \times 4 \times 0.05 = 0.8Watts$

$P_{res} = 16 \times .2 = 3.2Watts$ $P_{total} = 3.2 + 0.8 = 4Watts \le 4.5Watts$
Meets power requirement (circle this circuit)



$$R_1 = \frac{(20-(4 \times 4))}{0.05} = 80\Omega$$

Much less than current limit: 50 mA throughout and can use 225 mA
Voltage limit 4x4=16V < 20V so meets voltage requirement

$P_{diode} = 4 \times 4 \times 0.05 = 0.8Watts$

$P_{res} = (20-16) \times .05 = 0.2Watts$

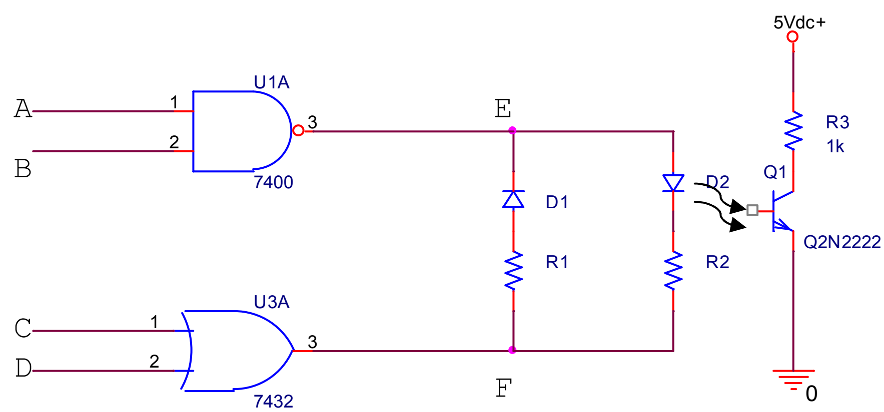
$P_{total} = 0.2 + 0.8 = 1Watt \le 4.5Watts$ Meets power requirement
Circle this one too

Question IV - LEDs and Phototransistor Circuits (continued)

3. (*4pt*) If you add one more diode in parallel to the parallel circuit above, which of the limits (current, voltage, and/or power) will it surpass? *This can be in addition to the limit it may surpass in the previous problem; mention all that apply now.*

Current limit and power limit (5 leds will now require 250mA. The max is 225 mA. The power limit is also surpassed with 1W from the diode and 4W from the LED. This is a total of 5W which is above 4.5 W from the source.)

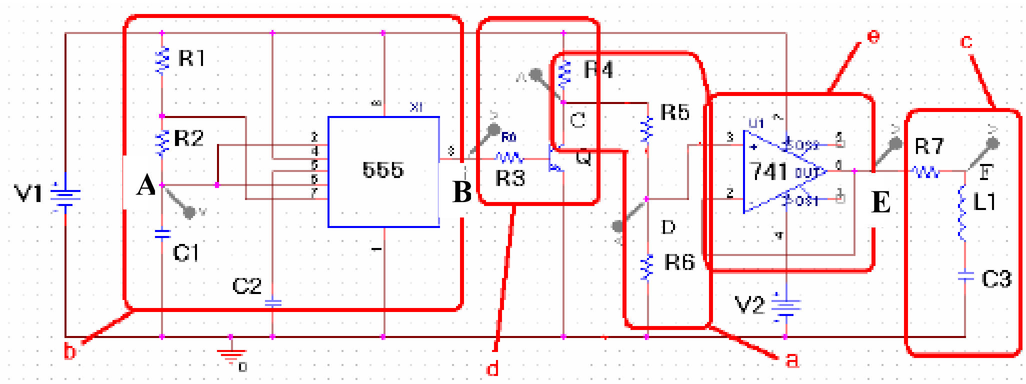
4. (*6pt*) Given the logic circuit below, fill in the chart using ***ON and OFF for D1 and D2***. ***Mark the collector voltage in Volts***. Assume that 0 is a low enough voltage to turn the diodes off, 1 is a high enough voltage to turn the diodes on, and the output voltages are identical for both logic gates.



A	B	C	D	E	F	D1	D2	collector
0	0	0	0					
0	1	0	1					
1	0	1	0					
1	1	1	1					

A	B	C	D	E	F	D1	D2	collector(V)
0	0	0	0	1	0	OFF	ON	0V
0	1	0	1	1	1	OFF	OFF	5V
1	0	1	0	1	1	OFF	OFF	5V
1	1	1	1	0	1	ON	OFF	0V

Question V – Signal Modulation and Functionality (20 points)



Assume the components have the following values:

C1=0.2 µF, C2=0.02µF, C3=0.068 µF
R1=1kΩ, R2=5kΩ, R3=1KΩ, R4=1kΩ, R5=6kΩ, R6=1kΩ, R7=50Ω
L1=5mH
V1=+15V
V2=-15V

1. (*5pt*) Identify the function of each of the blocks in the signal conditioning circuit above. Some blocks may match more than one function name and some function names may not be used.

Monostable multivibrator circuit ________
Voltage divider ________
Inverting amplifier ________
Comparator ________
Buffer amplifier (voltage follower) ________
Schmitt trigger ________
Voltage divider ________
RL circuit ________
A transistor circuit ________
Astable multivibrator circuit ________
RLC circuit ________

Monostable multivibrator circuit	N/A
Voltage divider	a
Inverting Amplifier	N/A
Comparator	N/A
Buffer amplifier (voltage follower)	e
Schmitt Trigger	N/A
RL Circuit	N/A
A transistor circuit	d
Astable multivibrator circuit	b
RLC Circuit	c

Question V – Signal Modulation and Functionality (continued)

2. (***2pt***) What is the general purpose of the circuit circled in **e**?

It is to keep the impedance of two different parts of the circuit from affecting each other.

3. (***3pt***) Calculate the frequency of the circuit in **b** in Hz

f=1/[0.693(R1+2R2)C1]=1/[0.693(1k+2*5k)*0.2μ]=656 Hz

4. (***10pt***) Fill in the voltages in the chart below based on the theoretical behavior of the circuit during normal astable (oscillating) operating mode. What are the min and max voltages that appear at each of the given points?

Voltage at pin 3	Point A	Point B	Point C	Point D	Point E
LOW					
HIGH					

Point A: This is the top of the capacitor at pin 2 and 6. Connected to the voltage divider thresholds. Va=1/3(V1)=1/3*15=5V low and Va=2/3(V1)=1/3(15)=10V high

Point B: The output pulses vary between 0 and V1 = 0V and 15V

Point C: When the output of the timer is low, the switch is open and Vc=15*(R5+R6)/(R4+R5+R6)=15(7K)/8K=13.1V
When the output of the timer is high the switch is closed = 0V

Point D: When Vc=13.1V, VD=Vc*R6/(R5+R6)=13.1*1K/(7K)=1.88V
When Vc=0 Vd=0V

Point E: It is a buffer circuit so the voltages will be the same as point D

Voltage at pin 3	Point A	Point B	Point C	Point D	Point E
LOW	5V	0V	13.1V	1.88V	1.88V
HIGH	10V	15V	0V	0V	0V