ECE 320 - Solution to Homework #4

Clipper, Max/Min, AC to DC Converters. Due Monday, September 18th, 2017

Clipper:

1) Design a circuit to approximate the following function.

- Input: X. 0 .. 10V signal, capable of driving 20mA
- Output: Y: 100k resistor
- Relationship: shown below
- Tolerance: +/- 1V

Step 1: Draw in straight line approximations to this function. If the voltage deviates by more than 1V, add another line (i.e. meet the requirements)

Shown in orange.

Add a resistor (1k shown here). This affects the overall gain of the circuit as

$$\left(\frac{100k}{100k+1k}\right) = 0.99$$

so the gain will be off by 1% under load (load = 100k), correct with no load (load = infinite)

Step 2: The initial slope is 1.36. Add an amplifier with a gain of 1.36

Step 3: On the Y axis, the voltages of the corners tell you the turn-on voltages for each leg. These are at

- 3V
- 5.5V

Step 4: When the output reaches 3V, the slope drops to 0.6. To get this

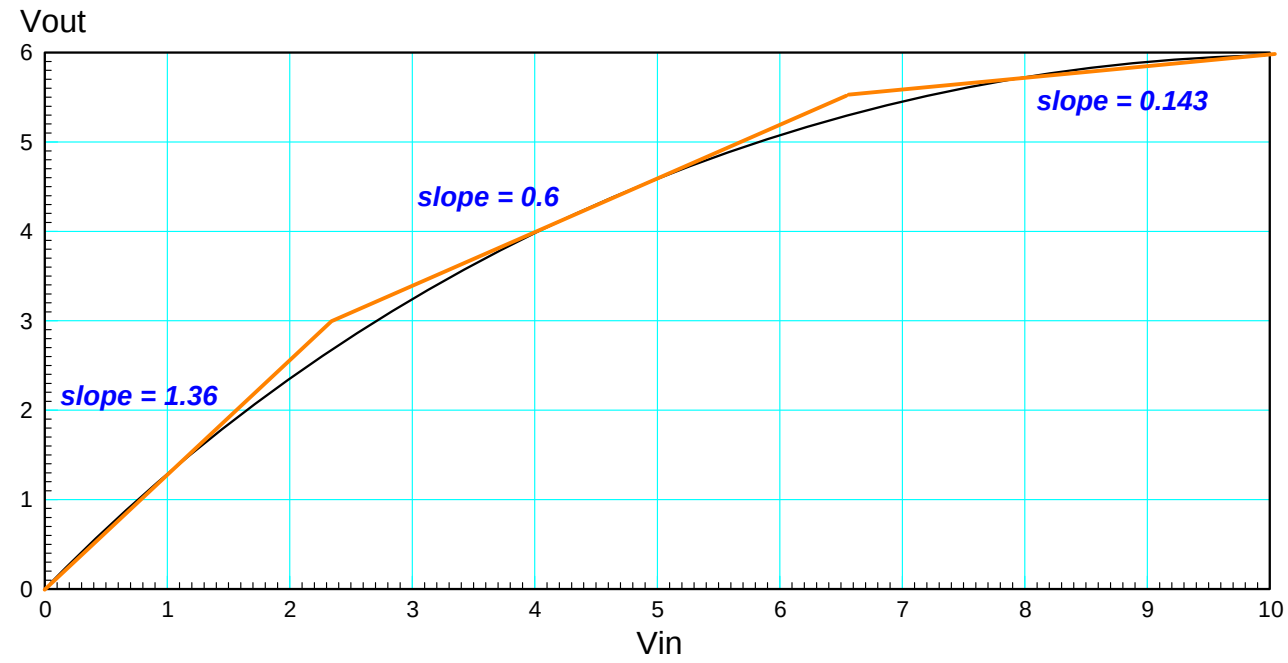
$$slope = 0.6 = \left(\frac{R}{R+1k}\right)1.36$$

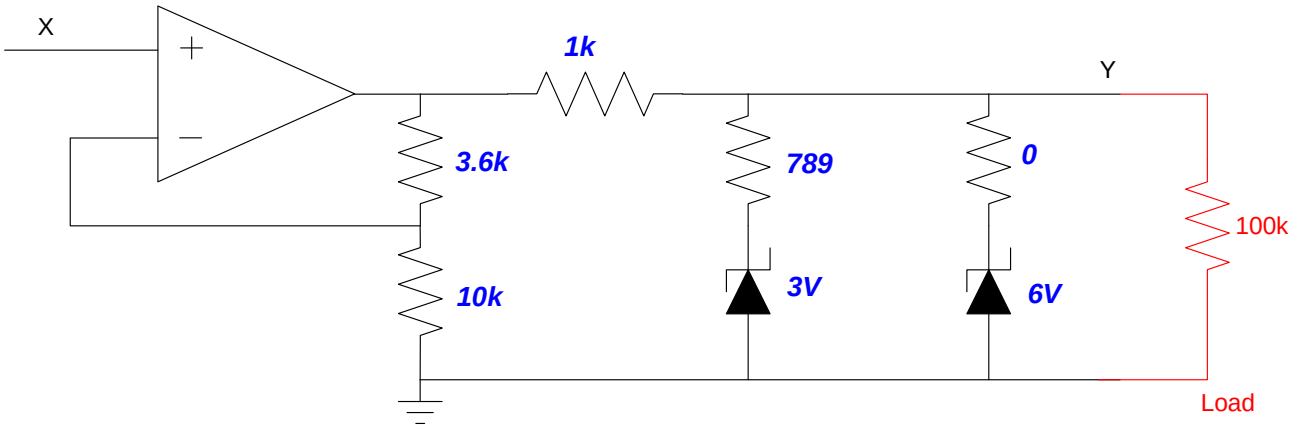
$$R = 789\Omega$$

When the output reaches 5.5V, the slope drops to 0.14. To get this slope

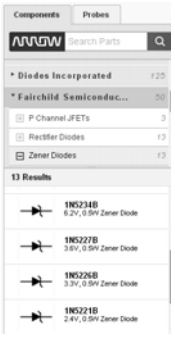
$$slope = 0.14 = \left(\frac{R}{R+1k}\right)1.36$$

$$R = 117\Omega$$

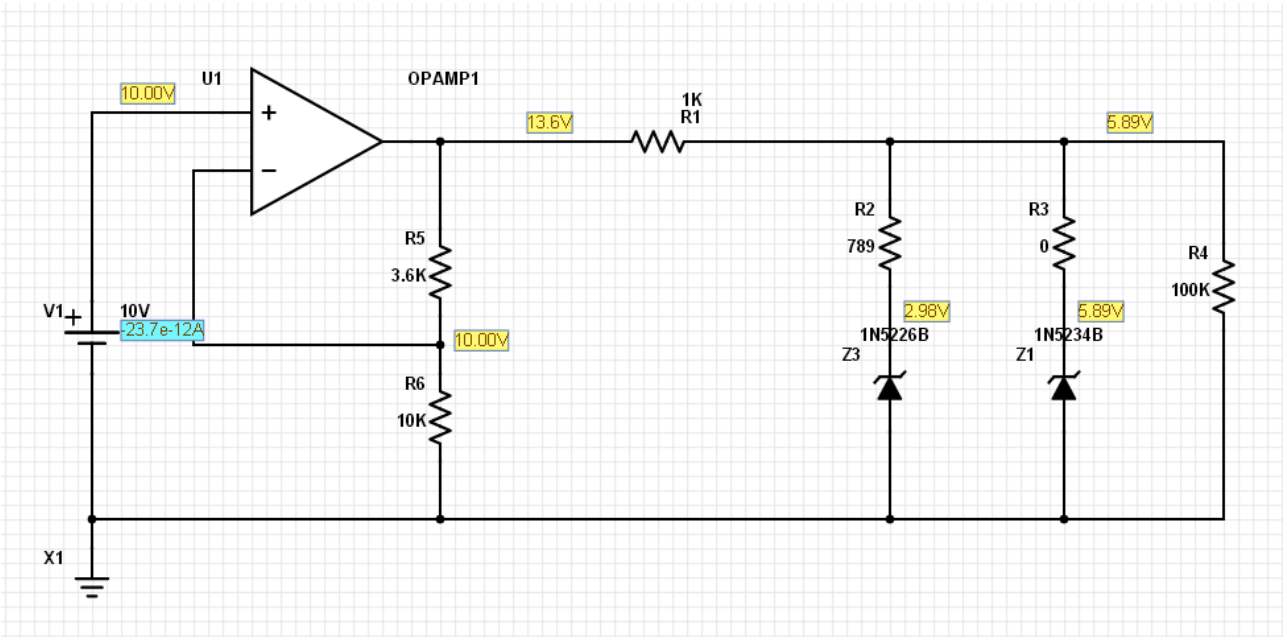

Vout
6
5
4
3
2
1
0
0
1
2
3
4
5
6
7
8
9
10
Vin
slope = 1.36
slope = 0.6
slope = 0.143

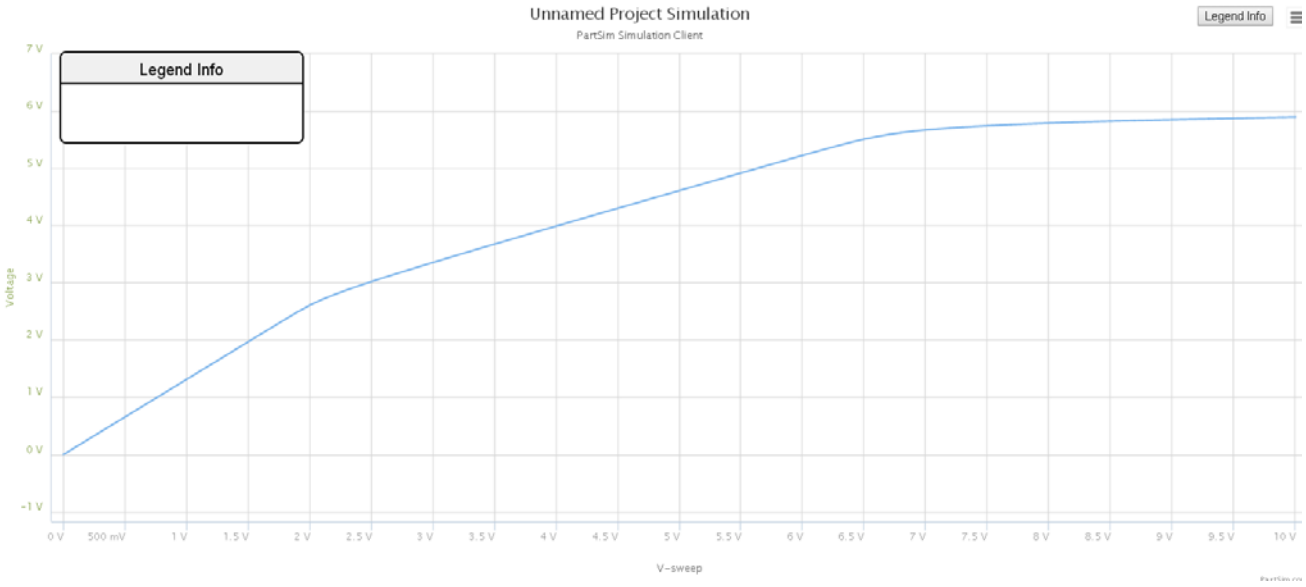

X
1k
Y
3.6k
789
0
100k
10k
3V
6V
Load

2) Check your design in PartSim (or similar program)



The zener diodes are a little hard to find exactly what I want. Fairchild Semiconductors has a lot of zeners - choose ones with a zener voltage of 3.3V and 6.3V (as close as I could get)





Max / Min

3a) Determine the voltages and currents for the following max/min circuit.

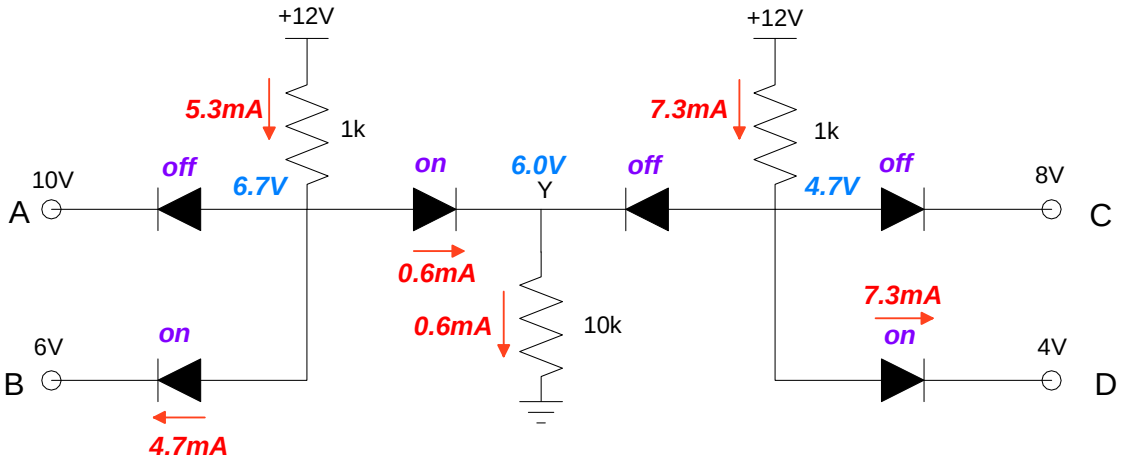
see below

3b) What function does this implement?

Y = f(A, B, C, D)

Y = max(min(A,B), min(C,D))

Y = AB + CD



AC to DC

Design a circuit to meet the following requirements:

- Input: 20Vp 60Hz sine wave capable of driving 500mA (i.e. wall transformers in lab)
- Output: 1k Ohm resistor
- Relationship: V2 is a DC signal with 200mVpp ripple when the load is 1k Ohm
- Tolerance: +/- 50mVpp ripple with a 1k Ohm load

4a) Assume L = 0. Determine C so that the ripple at V2 is 1Vpp.

The diode drops 0.7V, so the peak voltage at V1 is 19.3V

The current is (worst case)

$$I = \left(\frac{19.3V}{1k\Omega}\right) = 19.3mA$$

The capacitor is then

$$I = C\frac{dV}{dt}$$

$$19.3mA = C\frac{1V}{1/60s}$$

$$C = 312\mu F$$

4b) Determine L so that the ripple at V2 is rediced to 200mVpp

The inductor reduces the ripple from 1Vpp to 200mVpp (5x).

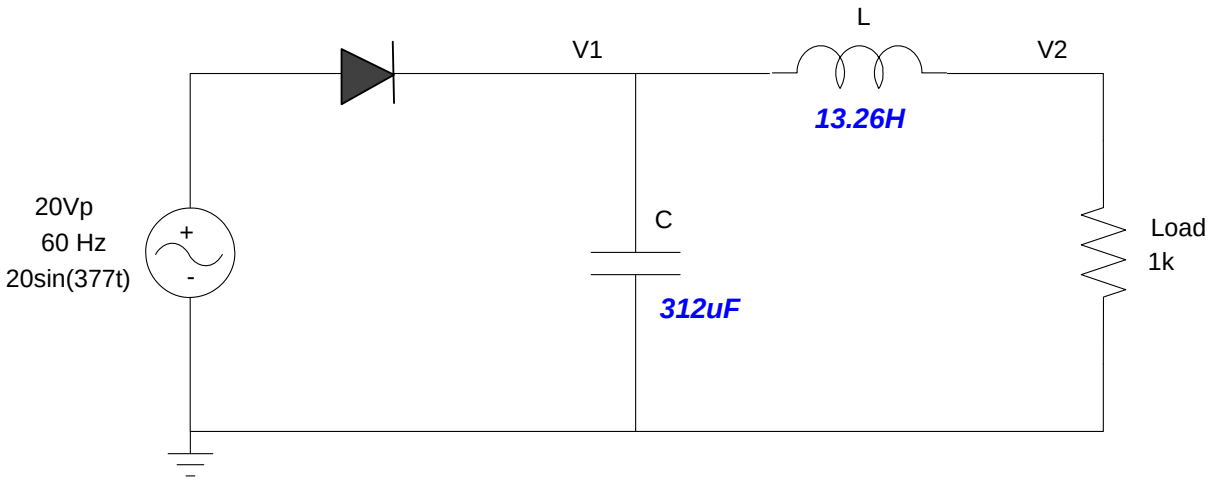
To do this, make the inductor 5x the load

$$j\omega L = j5000\Omega$$

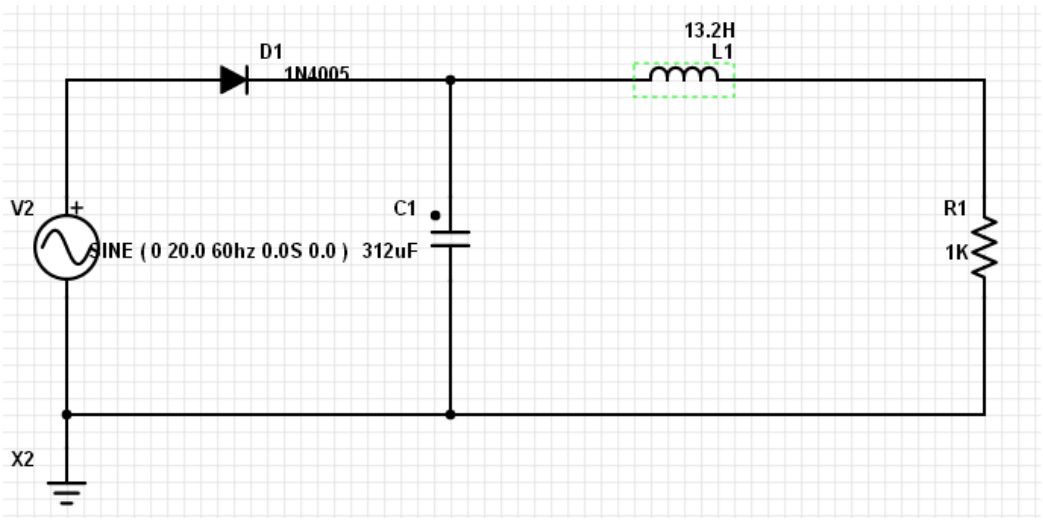
$$j \cdot 2\pi \cdot 60Hz \cdot L = j5000$$

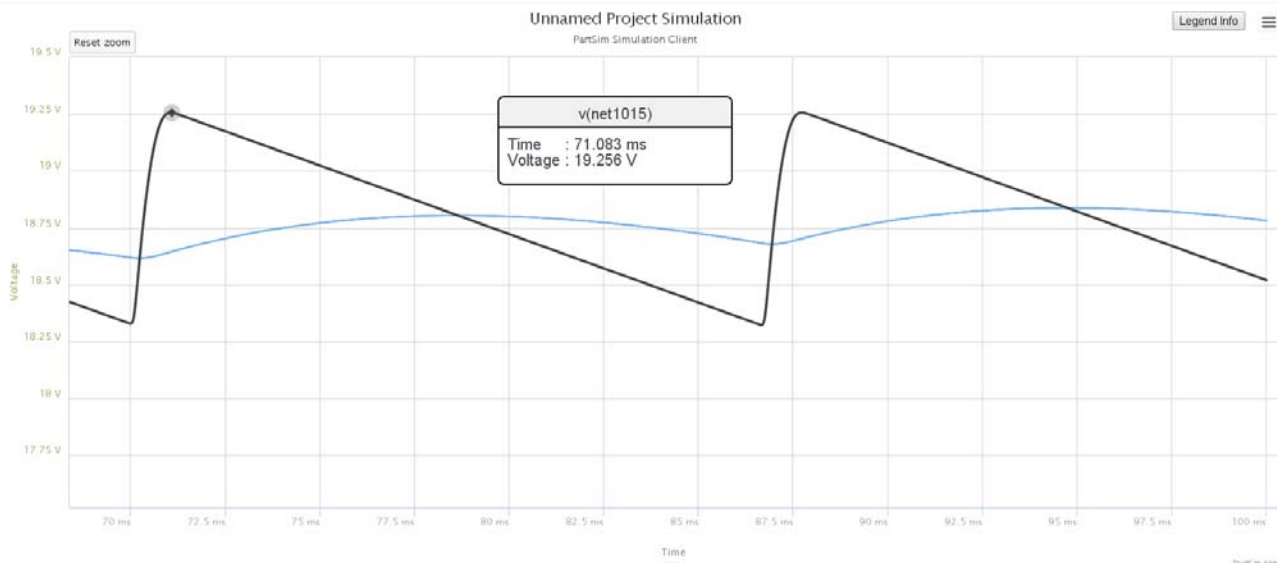
$$j \cdot 377 \cdot L = j5000$$

$$L = 13.26H$$



4c) Check your design in PartSim





	Calculation	Simluation	Lab
max(Vc)	19.3V	19.356V	
min(Vc)	18.3V	18.33V	
Vc pp	1Vpp	1.026Vpp	
max(Vr)		18.803V	
min(Vr)		18.616V	
Vr pp	200mVpp	187mVpp	

Lab:

6) Build and test one of these circuits in lab.