

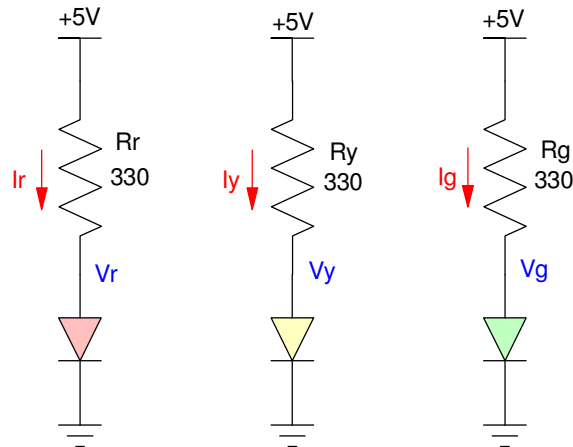
ECE 320 - Homework #3

LEDs, AC to DC Converter, Max/Min, Clippers

LEDs (Lab)

1) Using your lab kit, build the following circuits using a red, yellow, and green LED. When powered from +5V

- Using your multimeter, measure the voltage drop across each diode
- Compute the current through each LED



	R = 330 (prob 1)		R = 1000 (prob 2)	
	V_x	I_x	V_x	I_x
red	1.9871V	9.048mA	1.8853V	3.088mA
yellow	2.114V	8.664mA	2.004V	2.969mA
green	3.323V	5.000mA	2.512V	2.461mA



2) Change the resistors to 1k

- Measure the voltage drop across each LED
- If the current drops to 1/3rd of it previous value (R_x is 3x larger), does the voltage also drop to 1/3rd?
- Why or why not?

Data

- see previous table

3) Determine the values of the resistors so that the current in each diode is 20mA

Assume the voltage drop across each diode is constant (use voltages from problem #1)

Red

$$V_d \approx 1.9871V$$

$$R_r = \left(\frac{5V - 1.9871V}{20mA} \right) = 150.6\Omega$$

Yellow

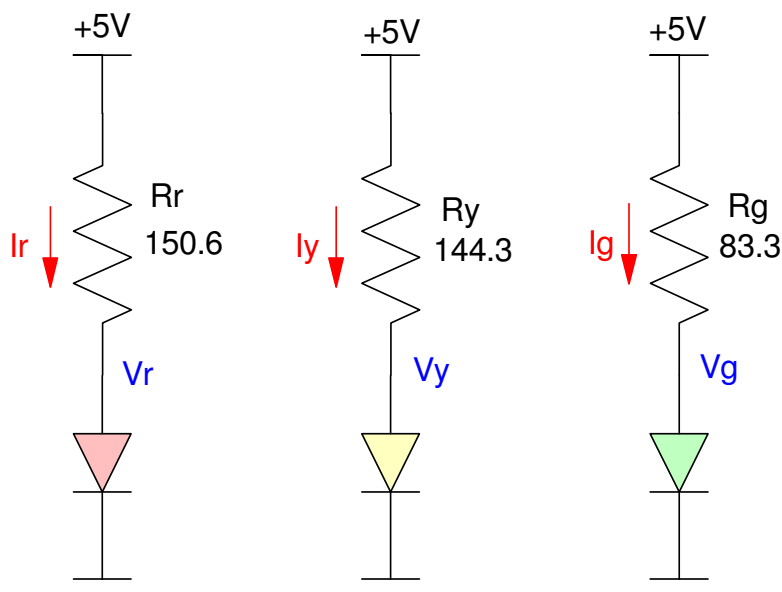
$$V_d \approx 2.114V$$

$$R_y = \left(\frac{5V - 2.114V}{20mA} \right) = 144.3\Omega$$

Green

$$V_d \approx 3.323V$$

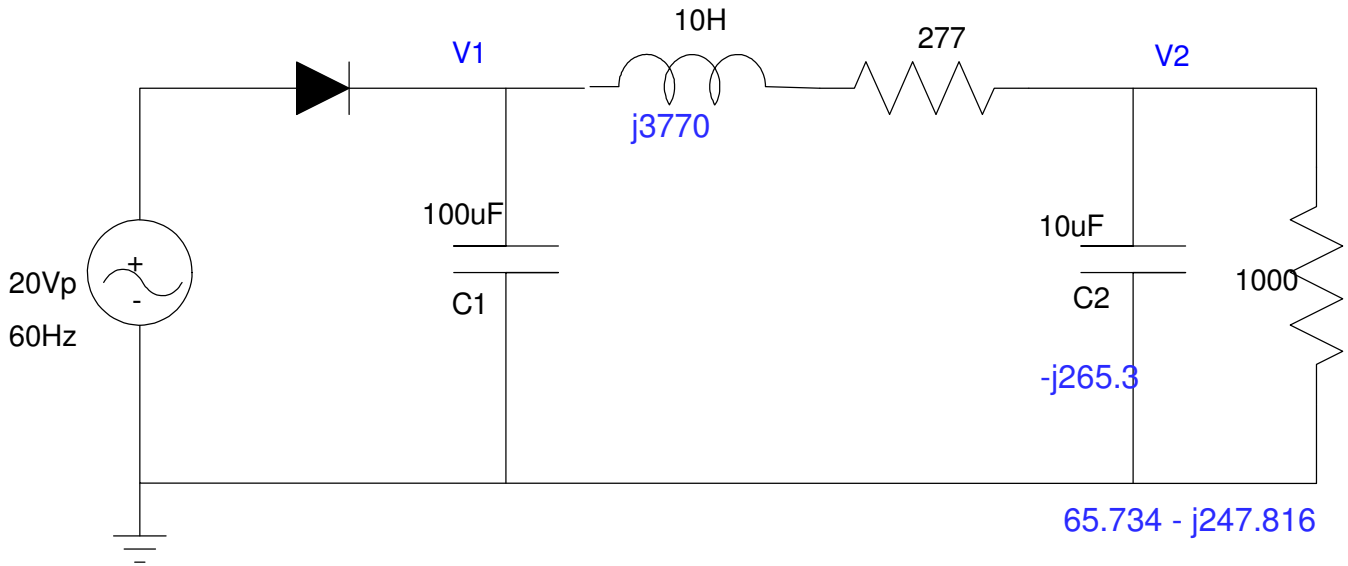
$$R_g = \left(\frac{5V - 3.323V}{20mA} \right) = 83.8\Omega$$



AC to DC Converters

For the circuit below:

4) Determine the voltages at V1 and V2 (DC and AC)



$$\max(V1) = 20V - 0.7V = 19.3V$$

$$I \approx \left(\frac{19.3V}{1000\Omega + 277\Omega} \right) = 15.11mA \quad \text{worst case}$$

For V1

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

$$15.11mA = 100\mu F \left(\frac{dV}{1/60s} \right)$$

$$dV = 2.519V \quad V1_{pp} (AC)$$

$$V1(AC) = 2.519V_{pp}$$

$$V1(DC) = 19.3V - \frac{1}{2}(2.519V_{pp}) = 18.04V$$

For V2

$$V2(DC) = \left(\frac{1000}{1000 + 277} \right) 18.04V = 14.13V$$

$$V2(AC) = \left(\frac{(65.734 - j247.816)}{(65.734 - j247.816) + (277 + j3770)} \right) 2.519V_{pp}$$

$$|V2(AC)| = 0.183V_{pp}$$

5) Determine C1 and C2 so that AC voltages are: $V_1 = 2V_{pp}$ and $V_2 = 250mV_{pp}$.

V1:

$$\max(V_1) = 19.3V$$

$$\min(V_1) = 17.3V \quad 2V_{pp}$$

$$V_1(DC) = 18.3V \quad (\max + \min) / 2$$

$$V_1(AC) = 2V_{pp} \quad given$$

$$I = \left(\frac{18.3V}{1277\Omega} \right) = 14.33mA$$

C1:

$$I = C_1 \frac{dV}{dt}$$

$$14.33mA = C_1 \left(\frac{2V}{1/60s} \right)$$

$$C_1 = 119.4\mu A$$

C2:

If $C_2 = 0$, then $V_2(AC)$ is

$$V_2(AC) = \left(\frac{(1000)}{(1000)+(277+j3770)} \right) (2V_{pp}) = 502.5mV_{pp}$$

To reduce $V_2(AC)$ to $250mV_{pp}$, the impedance of the capacitor needs to be about 1/2 of 1000 Ohms

$$|Z_c| = \left| \frac{1}{j\omega C} \right| = \left(\frac{250mV_{pp}}{502.5mV_{pp}} \right) 1000\Omega$$

$$\frac{1}{\omega C} = 497.6\Omega$$

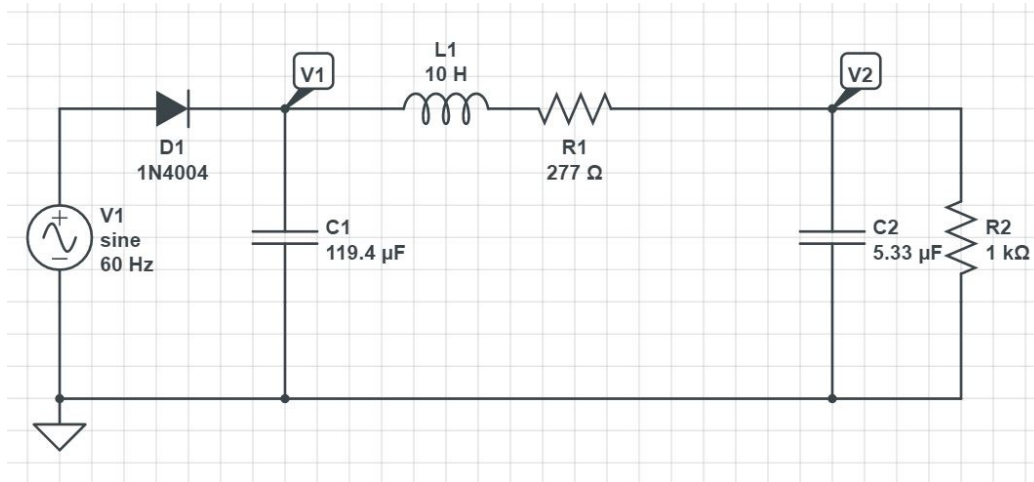
$$C_2 = 5.33\mu F$$

So

$$C_1 = 119.4\mu F$$

$$C_2 = 5.33\mu F$$

6) Build this circuit in CircuitLab (or similar program) and verify your calculations for problem #8



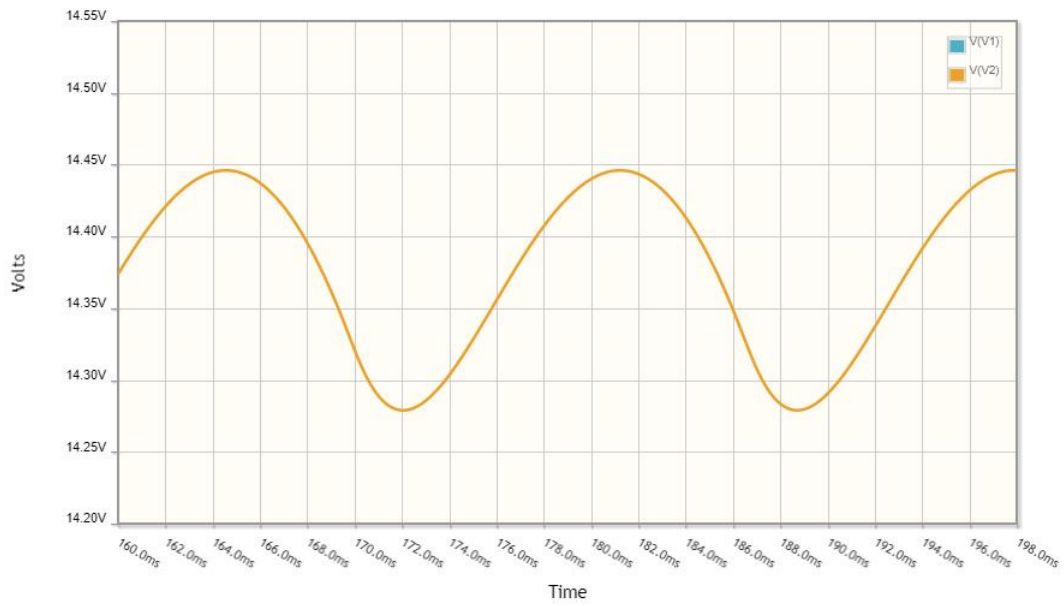
Running a transient simulation results in

- $\max(V1) = 19.25\text{V}$
- $\min(V1) = 17.41\text{V}$
- $V1(\text{DC}) = \text{mean}(\max, \min) = 18.33\text{V}$ (vs. 18.30 calculated)
- $V1(\text{AC}) = \max - \min = 1.840\text{Vpp}$ (vs. 2.00V calculated)



For V2

- $\max(V2) = 14.45V$
- $\min(V2) = 14.28V$
- $V2(DC) = \text{mean}(\max, \min) = 14.365V$
- $V2(AC) = \max - \min = 170mV_{pp}$ (vs. $250mV_{pp}$ calculated)



Max/Min:

7) Determine the voltages and currents for the following max/min circuit. What function does this circuit implement?
 $Y = f(A, B, C, D)$

$$I_1 = 0$$

$$I_2 = 4.7\text{mA} \quad (I_2 + I_3 = 5.3\text{mA})$$

$$I_3 = 0.6\text{mA}$$

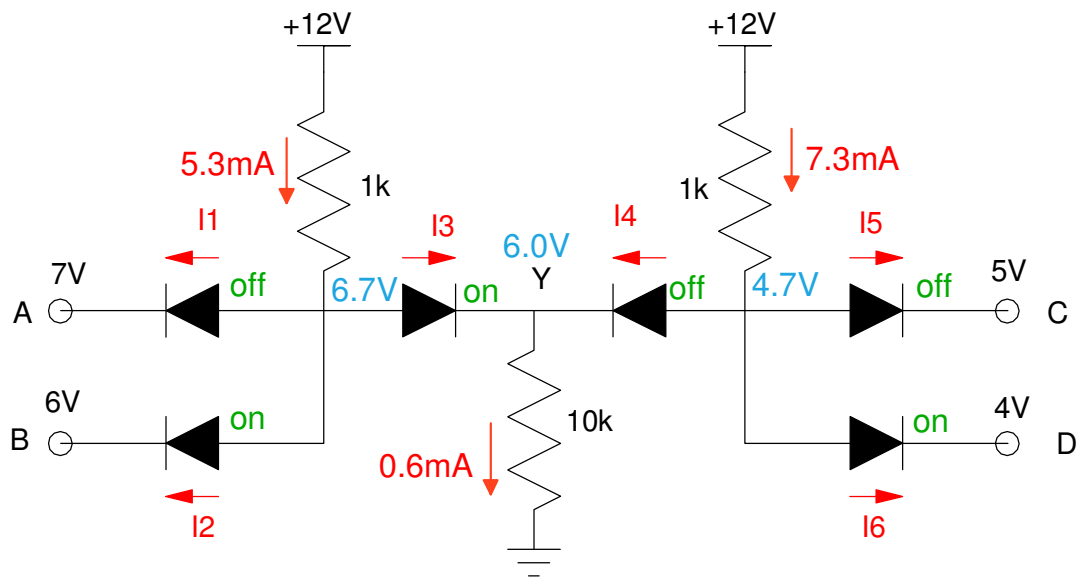
$$I_4 = 0$$

$$I_5 = 0$$

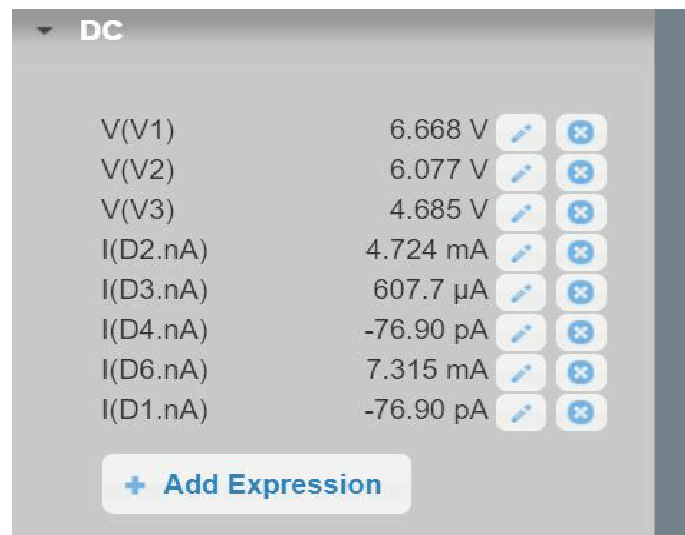
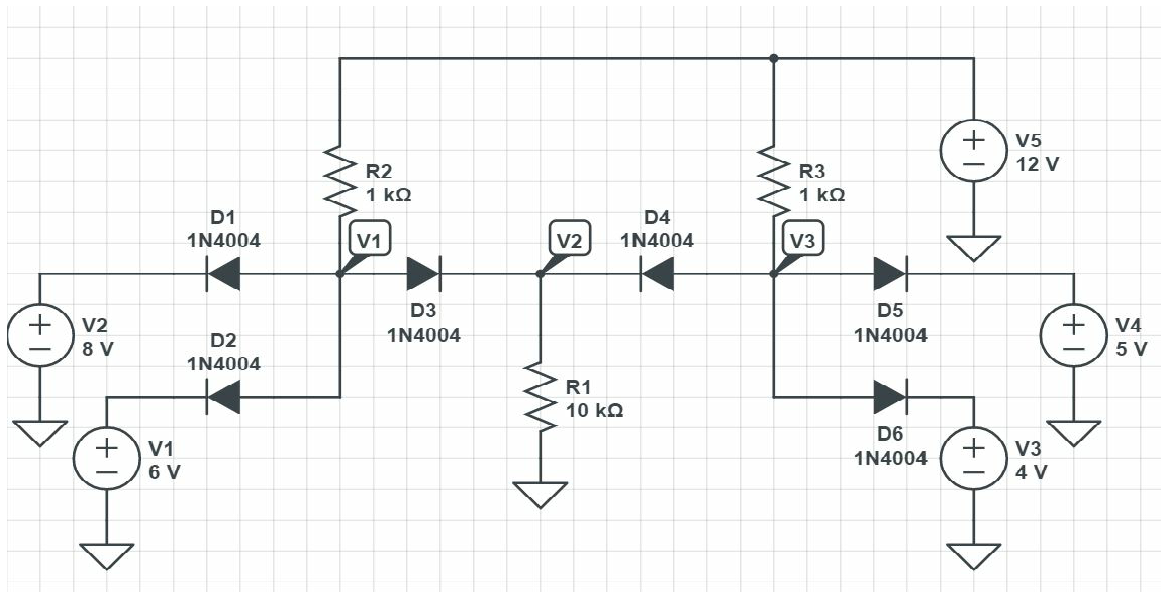
$$I_6 = 7.3\text{mA}$$

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

$$Y = AB + CD$$



8) Check your results in CircuitLab (or similar program)

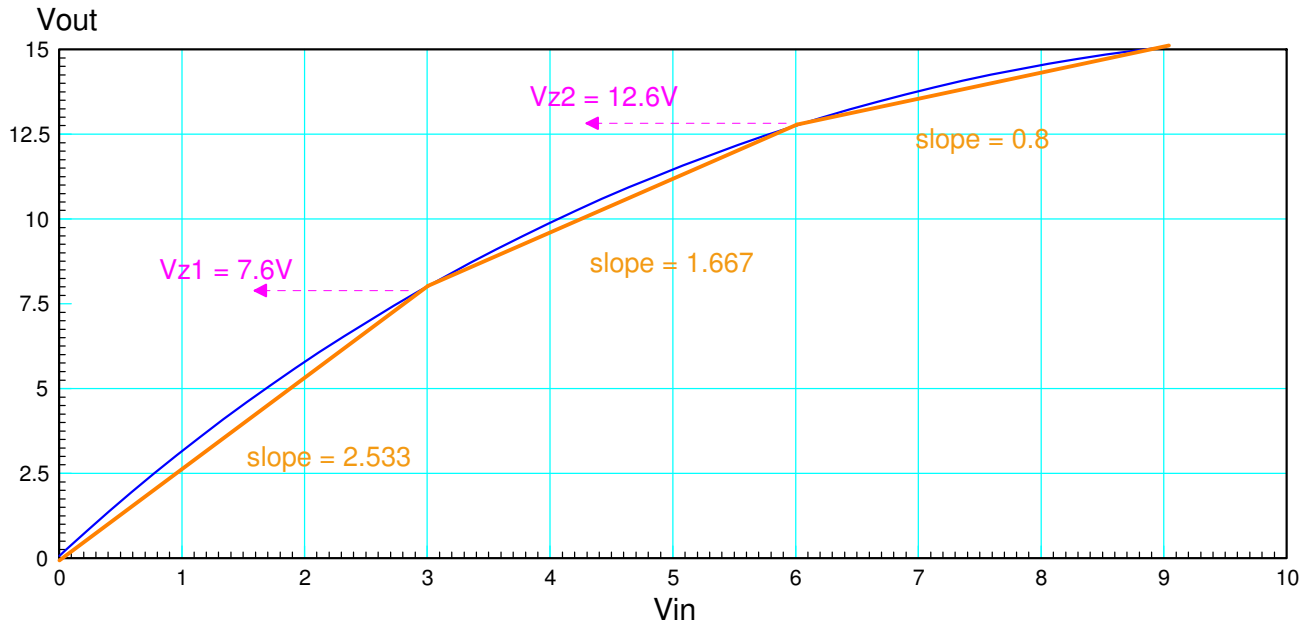


	V1	V2	V3	Id2	Id3	Id6
calculated	6.7 V	6.0 V	4.7 V	4.7 mA	0.6 mA	7.3 mA
CircuitLab	6.668V	6.077V	4.685V	4.724mA	0.6077mA	7.315mA

Clipper Circuits:

9) Design a circuit to approximate the following function subject to the following requirements:

- Input: 0 .. 10V, capable of 100mA
- Output: 100k resistor
- Relationship: Graph below, +/- 200mV



Gain = 2.533

$$gain = 1 + \frac{R_0}{1k} = 2.533$$

$$R_0 = 1.533k$$

Gain = 1.667

$$gain = (2.533) \left(\frac{R_1}{R_1 + 1k} \right) = 1.667$$

$$R_1 = 1925$$

Gain = 0.8

$$gain = 2.533 \left(\frac{R_{12}}{R_{12} + 1k} \right) = 0.8$$

$$R_{12} = R_1 || R_2 = 462$$

$$R_2 = 607$$

10) Check your design in CircuitLab

