ECE 320 - Homework #4

Max/Min Circuits, Clipper Circuits, Transistor Theory. Due Monday, February 8th

Max/Min:

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

I1 = 0

I2 = 4.7mA (I2 + I3 = 5.3mA)

I3 = 0.6mA

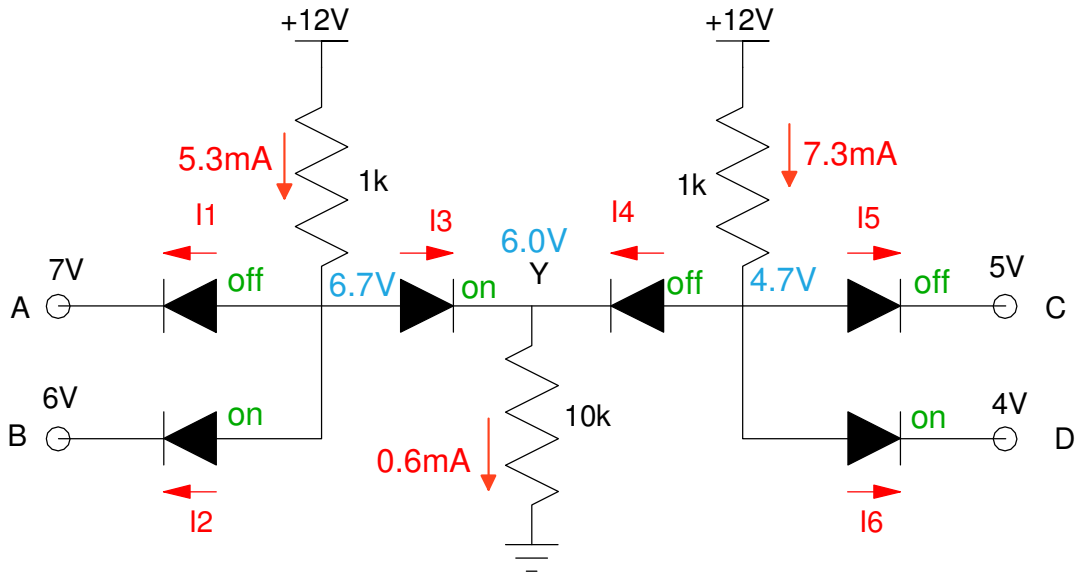
I4 = 0

I5 = 0

I6 = 7.3mA

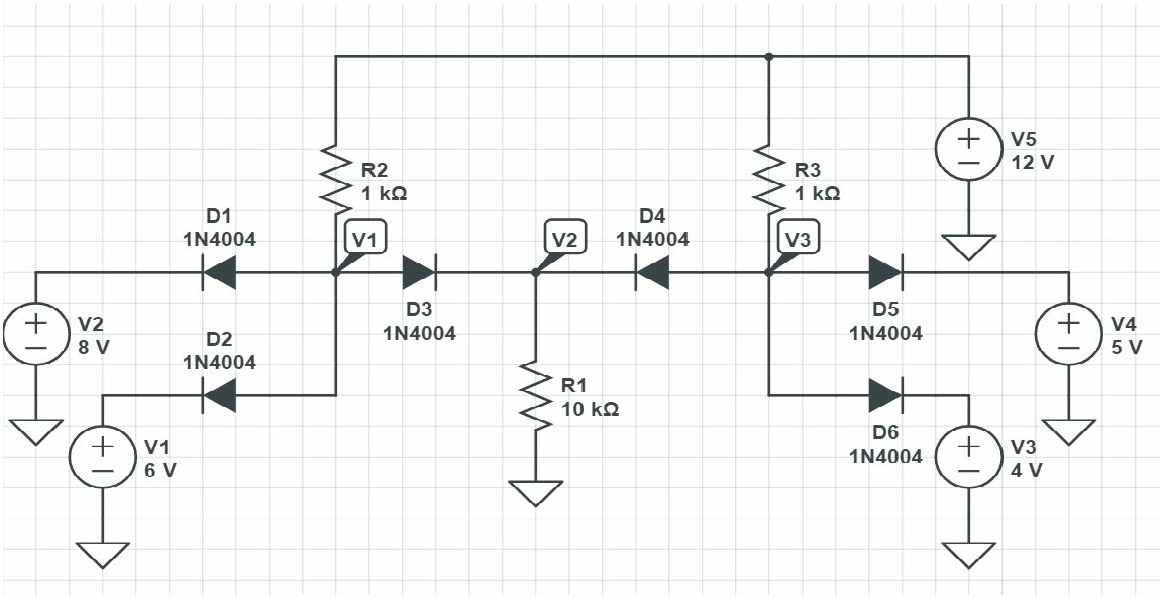
Y = max(min(A,B), min(C,D))

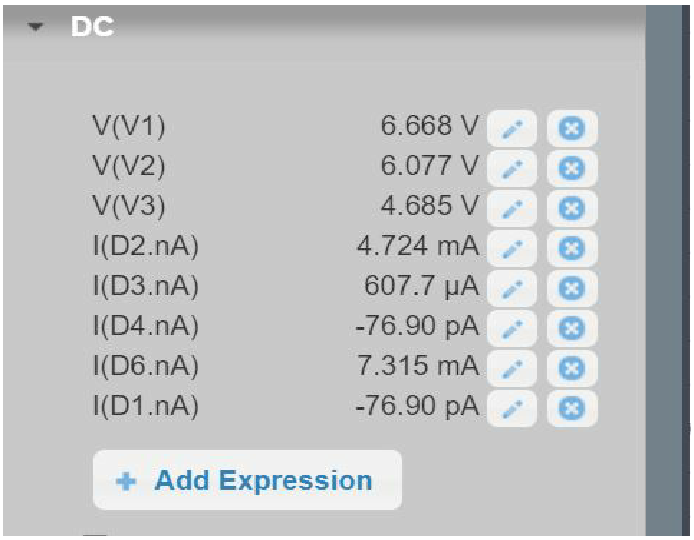
Y = AB + CD



Problem 1-2.

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



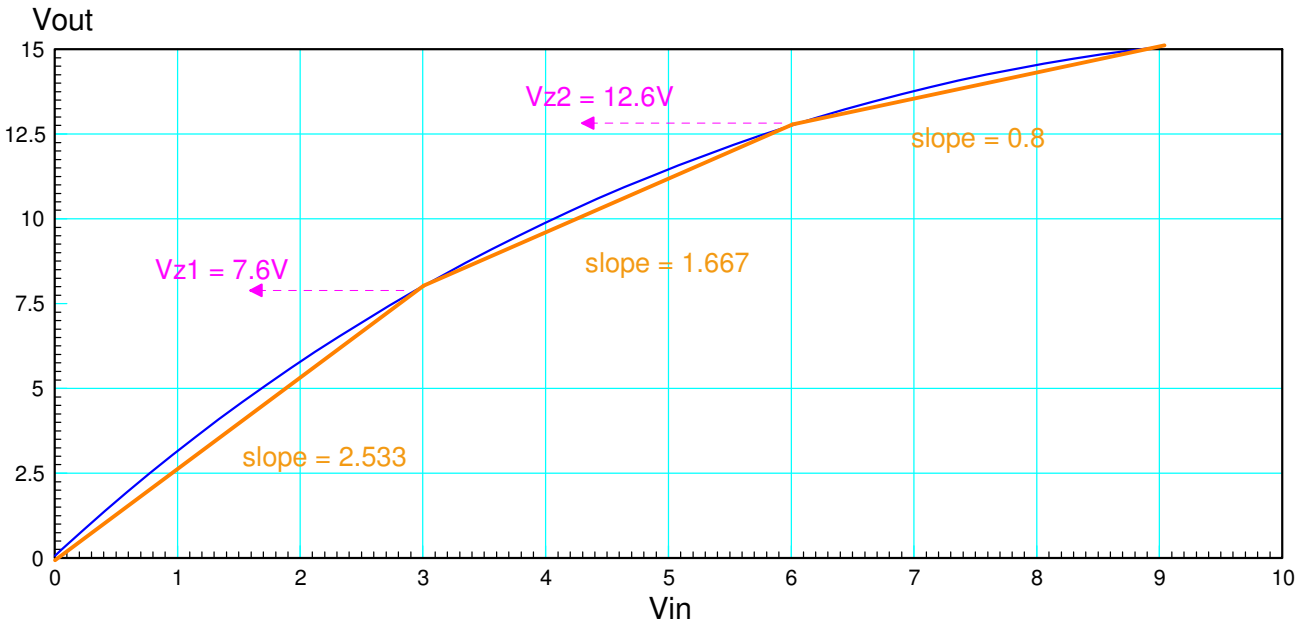


	V1	V2	V3	Id2	Id3	Id6
calculated	6.7 V	6.0 V	4.7 V	4.7 mA	0.6 mA	7.3 mA
CircuitLab	6.668V	6.077V	4.685V	4.724mA	0.6077mA	7.315mA

Clipper Circuits:

3) 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

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

$$R_1 = 1925\Omega$$

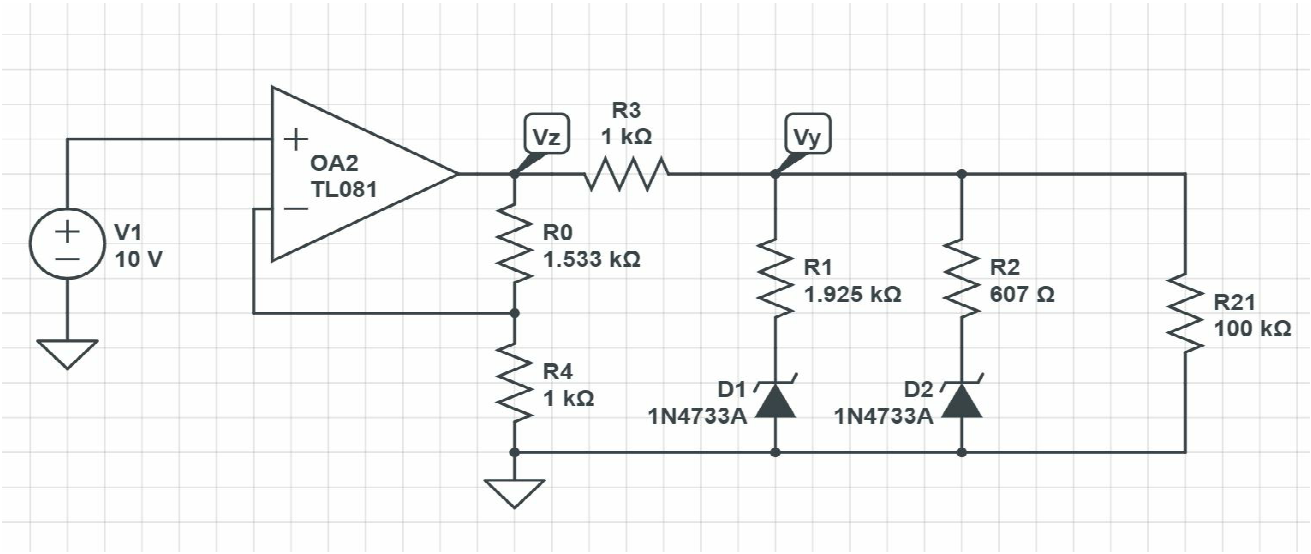
Gain = 0.8

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

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

$$R_2 = 607\Omega$$

4) Check your design in CircuitLab

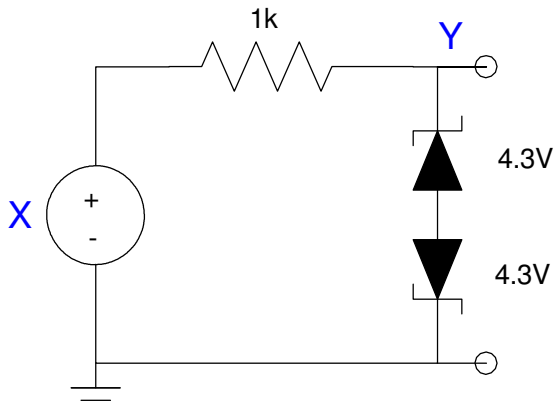


5) Design a circuit which meets the following requirements:

- Input: -10 .. +10V, capable of 100mA
- Output: 1k resistor
- Relationship:

$$V_{out} = \begin{cases} +5V & V_{in} > +5V \\ V_{in} & -5V < V_{in} < +5V \\ -5V & V_{in} < -5V \end{cases}$$

Use two 4.3V zener diodes back-to-back in series



Transistors

6) Determine the current gain, β, for the transistor show below. Also label the off, active, and saturated regions.

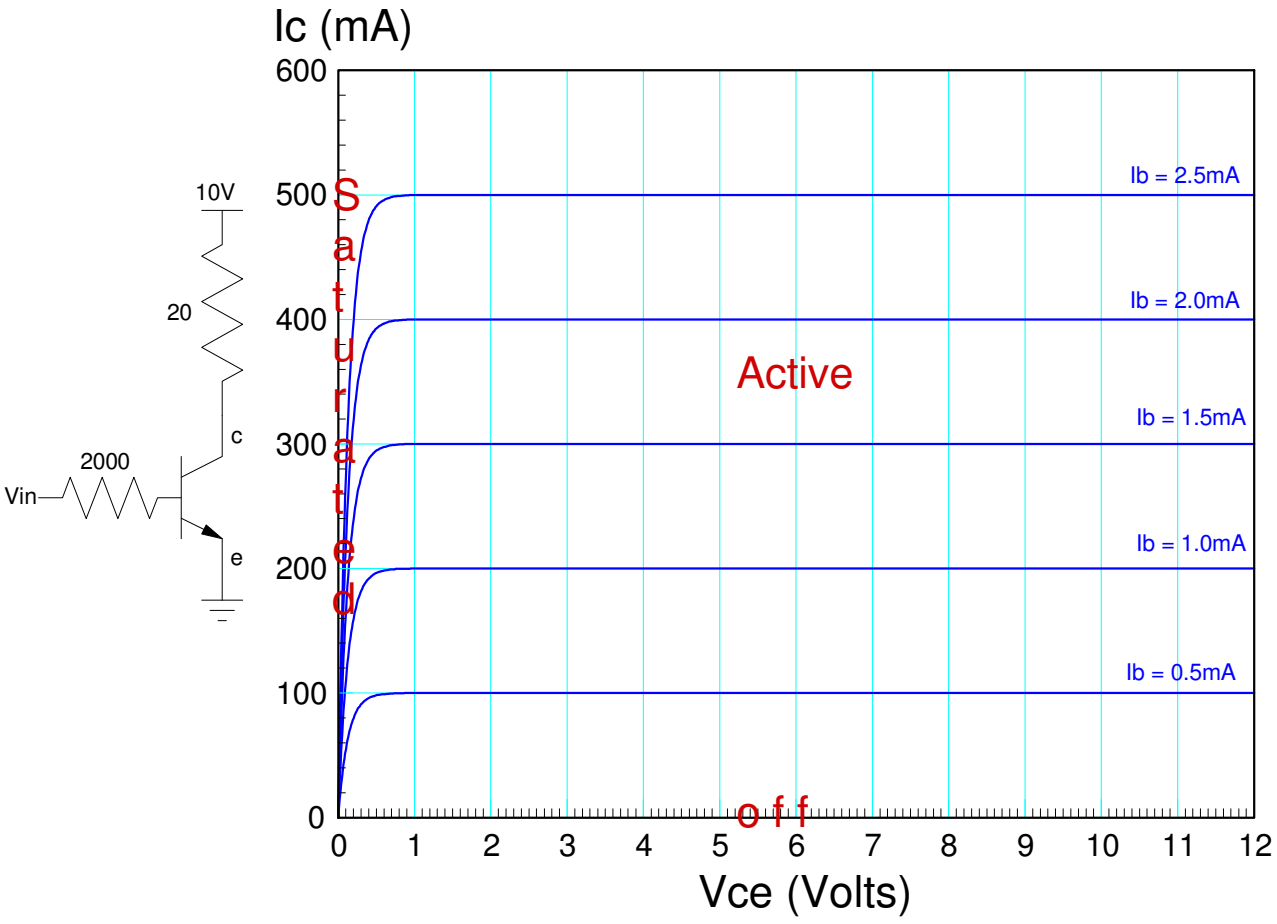
Pick a point in the active region, such as

- Ib = 2.5mA
- Ic = 500mA
- Vce = 11V (doesn't matter)

The gain is

$$I_c = \beta I_b$$

$$\beta = \left(\frac{500mA}{2.5mA}\right) = 200$$



7) Draw the load-line and determine the Q-point for

- Vin = 0V, 3V, 6V

Vin = 0V

- Ib = 0
- Ic = 0
- Vc = 5 - 20 Ib = 5V

Vin = 3V

$$I_b = \left(\frac{3-0.7}{2000}\right) = 1.15mA$$

$$I_c = 200I_b = 230mA$$

$$V_{ce} = 10 - 20I_c = 5.40V$$

Vin = 6V

$$I_b = \left(\frac{6-0.7}{2000}\right) = 2.65mA$$

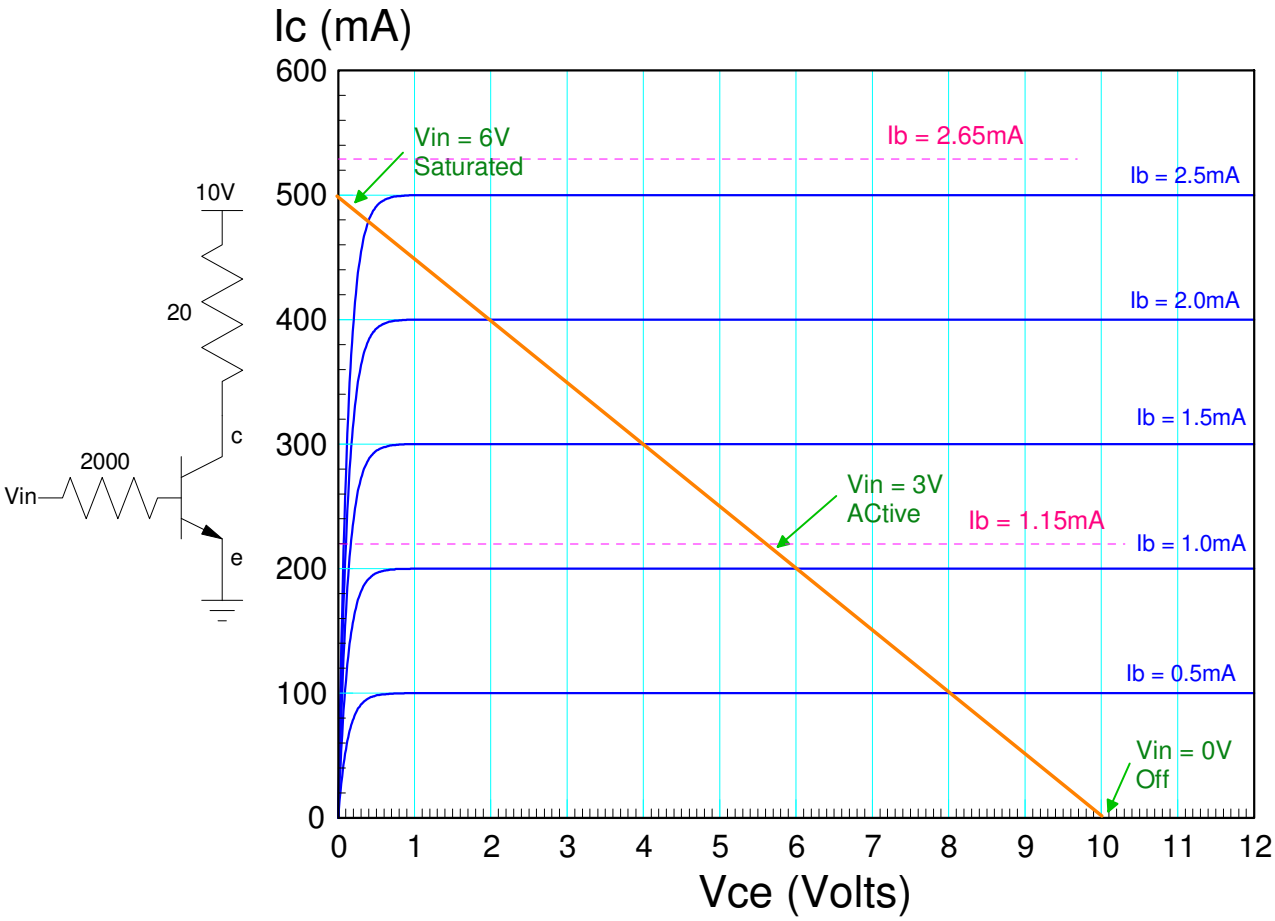
$$I_c = 200I_b = 530mA \qquad \textit{if active}$$

$$V_{ce} = 10 - 20I_b = -0.60V \qquad \textit{if active}$$

That can't happen, so it's not active. Instead, it's saturated

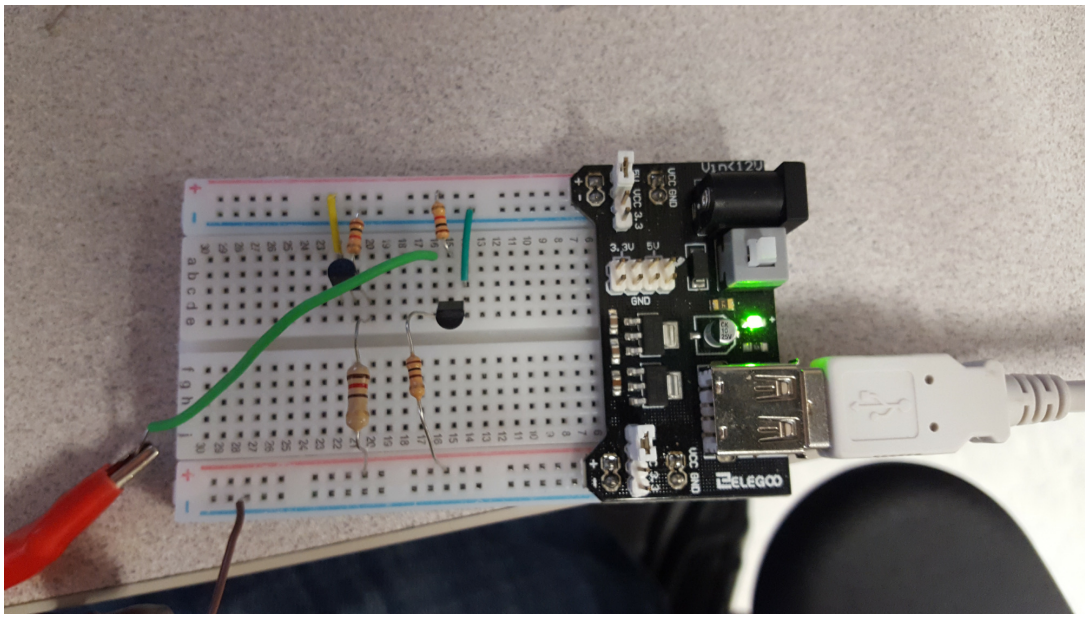
$$V_{ce} = 0.2V$$

$$I_c = \left(\frac{10V-0.2V}{20}\right) = 490mA$$



Problem 6 - 7

Lab (over)



Lab: Please include a photo of your circuit to receive credit for problems 8-10

8-10) Build the following circuit with your electronics kit.

- Measure Vce and Ic for 1k < Rb < infinity.
- Determine the operating point for each conidition and the current gain for your 3904 transistor
- Draw the load line on the graph below and mark each point you measured

Rb	Vbe	Vce	Ib	Ic	Current Gain (Ic/Ib)	Operating Region (off / active / saturated)
1k br - bl - re	0.777	0.045	4.393 mA	51.25 mA	11.67	saturated
10k br - bl - or	0.730	0.109	444 uA	50.61 mA	114	saturated
100k br - bl - ye	0.672	4.05	44.98 uA	11.2 mA	249	active
1M br - bl - gr	0.605	4.98	4.56 uA	1.90 mA	416	active
infinity	0	5.17	0	0	?	off