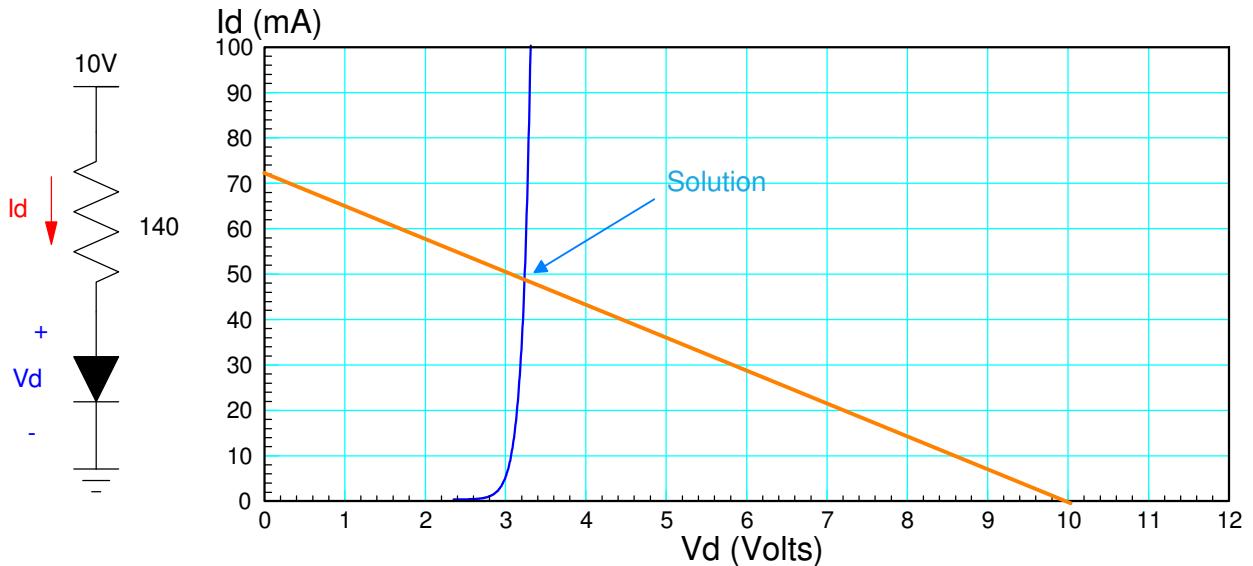


ECE 320 - Final (part 1) - Name _____

Semiconductors and Diode Circuits

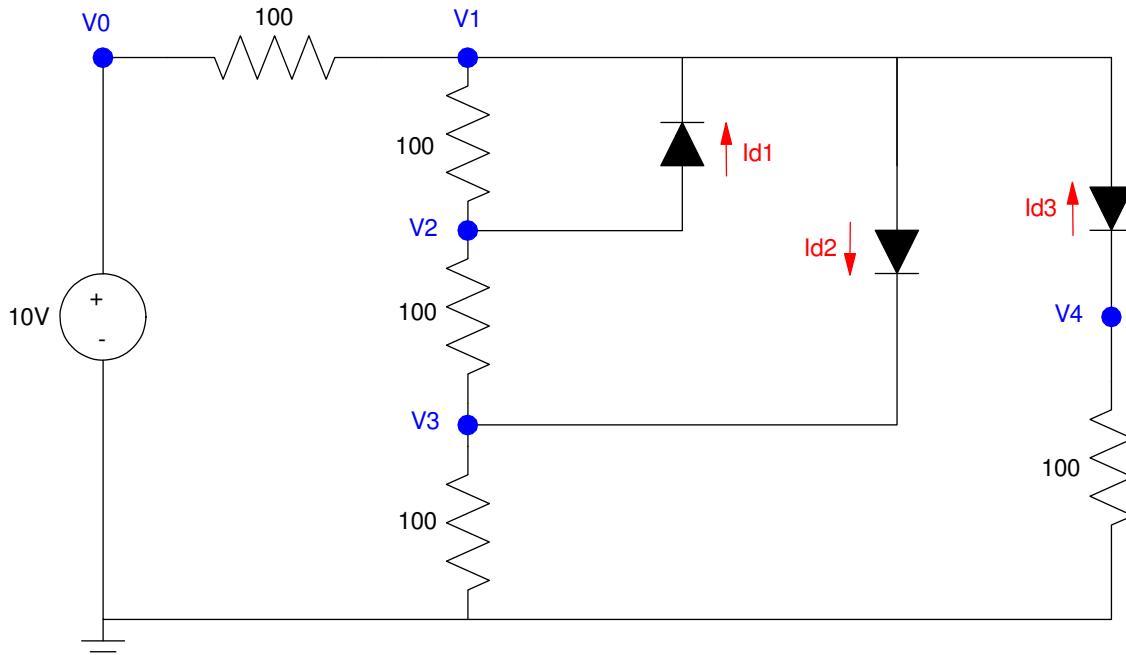
1) Load Lines (diode). Draw the load line and determine V_d and I_d for the following diode circuit

Load Line	Q-Point (V_d)	Q-Point (I_d)
show on graph	3.2V	48mA



2) Diode Circuits (nonlinear equations). Write the voltage node equations for the following diode circuit. Assume non-ideal diodes with

$$V_d = 0.052 \ln(10^8 I_d + 1) \quad I_d = 10^{-8} \left(\exp\left(\frac{V_d}{0.052}\right) - 1 \right)$$



$$I_{d1} = 10^{-8} \left(\exp\left(\frac{V_2 - V_1}{0.052}\right) - 1 \right)$$

$$I_{d2} = 10^{-8} \left(\exp\left(\frac{V_1 - V_3}{0.052}\right) - 1 \right)$$

$$-I_{d3} = 10^{-8} \left(\exp\left(\frac{V_1 - V_4}{0.052}\right) - 1 \right)$$

$$\left(\frac{V_1 - 10}{100}\right) + \left(\frac{V_1 - V_2}{100}\right) - I_{d1} + I_{d2} - I_{d3} = 0$$

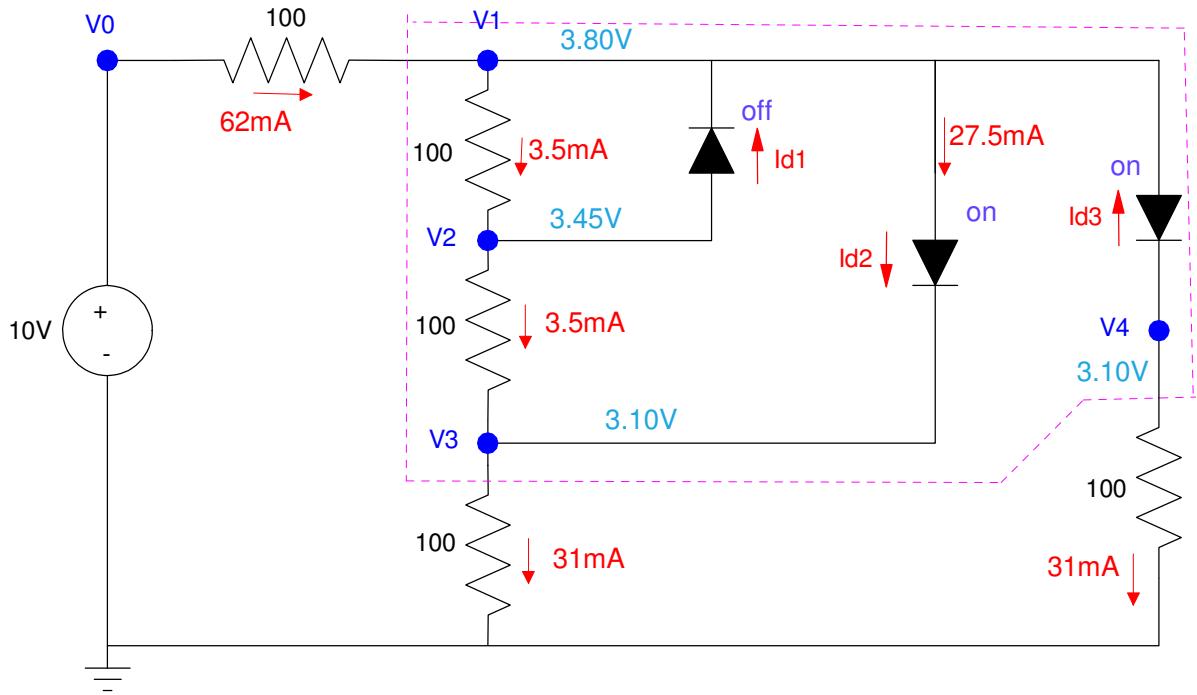
$$\left(\frac{V_2 - V_1}{100}\right) + \left(\frac{V_2 - V_3}{100}\right) + I_{d1} = 0$$

$$\left(\frac{V_3 - V_2}{100}\right) + \left(\frac{V_3}{100}\right) - I_{d2} = 0$$

$$\left(\frac{V_4}{100}\right) + I_{d3} = 0$$

3) Assuming ideal silicon diodes ($V_f = 0.7V$), determine the voltages and currents

V1	V2	V3	Id1	Id2	Id3
3.80V	3.45V	3.10V	0	27.5mA	-31mA



$$V_3 = V_1 - 0.7$$

$$V_4 = V_1 - 0.7$$

$$\left(\frac{V_1-10}{100}\right) + \left(\frac{V_1-0.7}{100}\right) + \left(\frac{V_1-0.7}{100}\right) = 0$$

$$V_1 = 3.80V$$

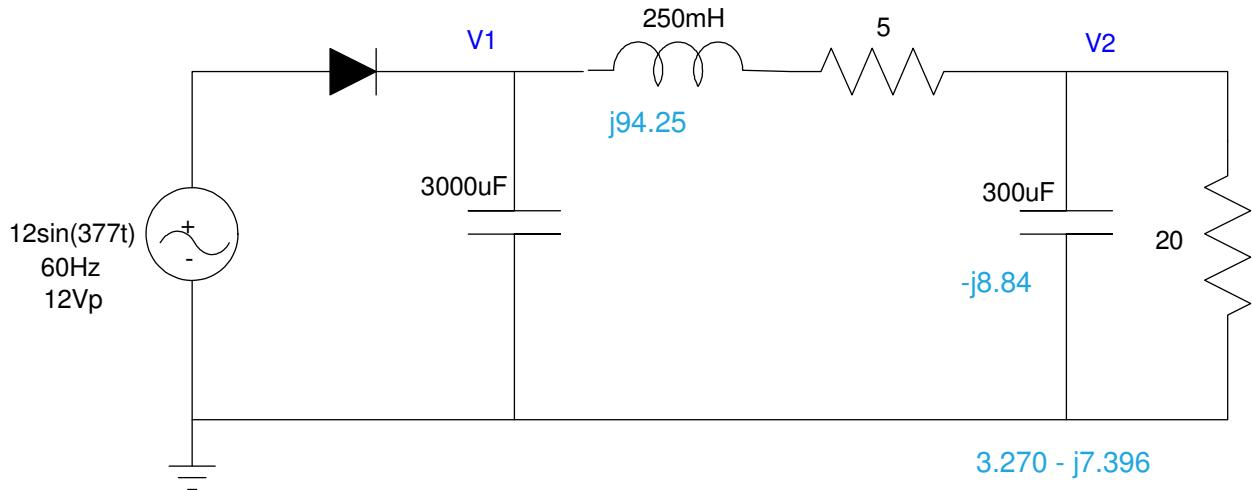
$$V_3 = 3.10V$$

$$V_4 = 3.10V$$

$$V_2 = 3.45V$$

4) AC to DC converter: Determine the voltages (DC and AC) for the following DC to AC converter. Assume ideal silicon diodes ($V_f = 0.7V$)

V1		V2	
V1(DC)	V _{pp} (AC)	V2(DC)	V _{2pp} (AC)
10.04V	2.511V_{pp}	8.036V	0.233 V_{pp}



$$\max(V_1) = 11.3V$$

$$I \approx \left(\frac{11.3V}{25\Omega} \right) = 452mA$$

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

$$452mA = 3000\mu F \frac{dV}{1/60s}$$

$$dV = 2.511V = V_{1pp}$$

$$V_1(DC) = 11.3V - \frac{1}{2}V_{1pp} = 10.04V$$

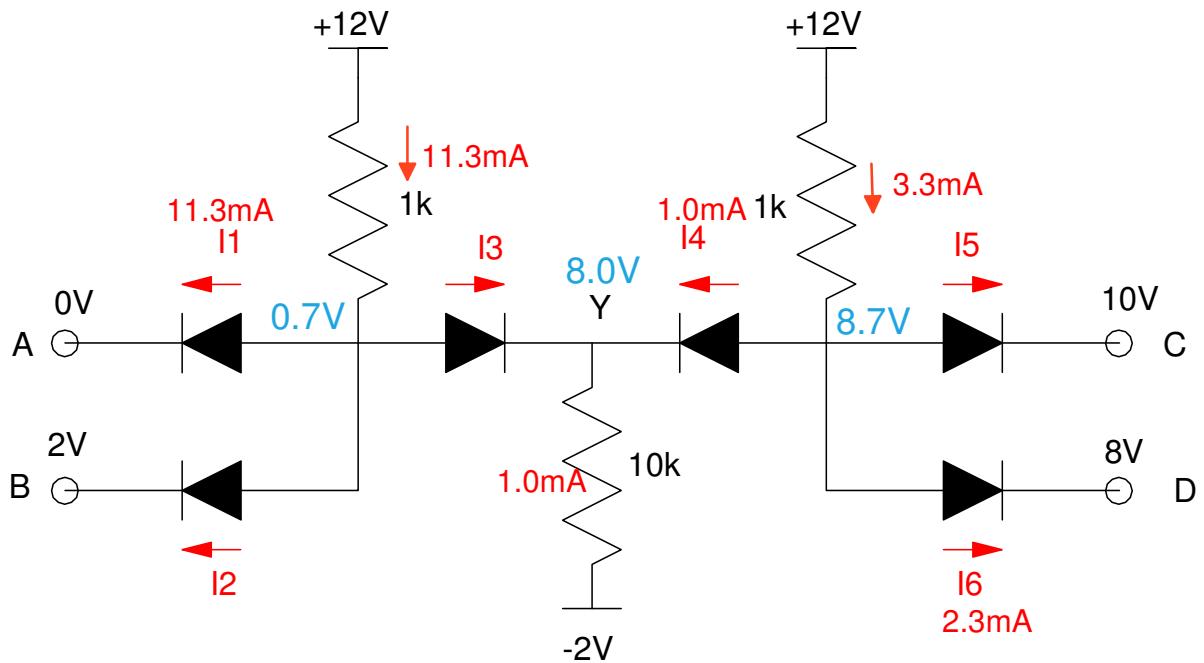
$$V_2(DC) = \left(\frac{20}{20+5} \right) 10.04V = 8.036V$$

$$V_2(AC) = \left(\frac{(3.2708-j7.396)}{(3.2708-j7.396)+(5+j94.25)} \right) (2.511V_{pp})$$

$$V_2(AC) = 0.233V_{pp}$$

5) Max/Min: Determine the currents for the following max/min circuit. Assume ideal silicon diodes.

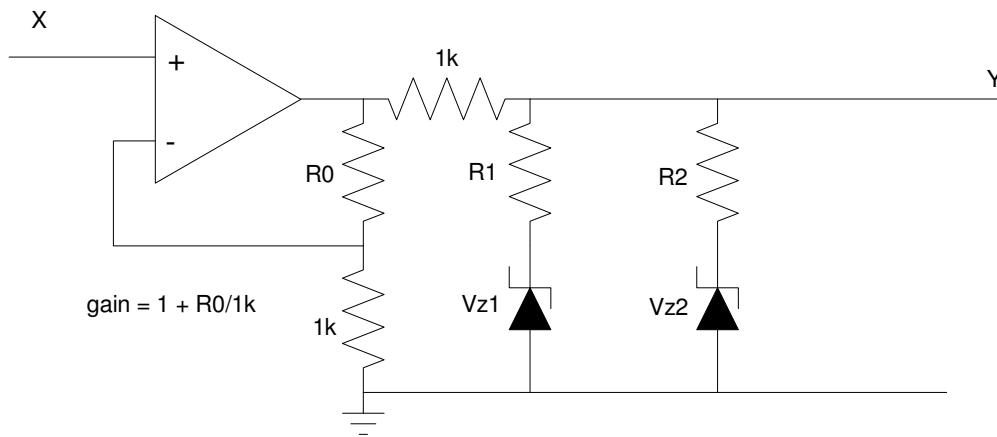
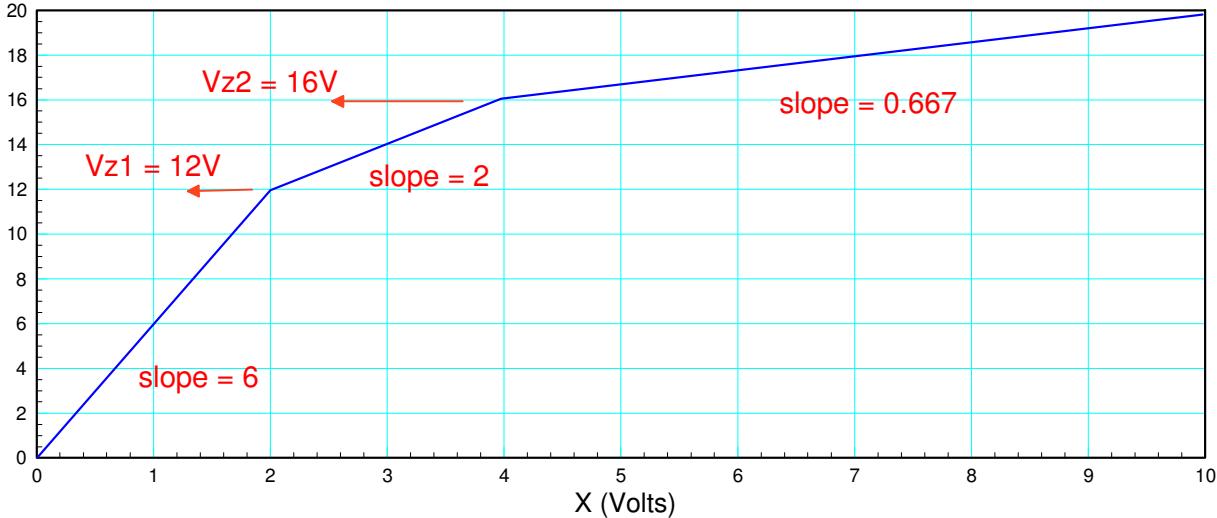
I1	I2	I3	I4	I5	I6
11.3mA	0	0	1.0mA	0	2.3mA



6) Clipper Circuits: Determine the resistances and zener voltages to implement the following function

R0	R1	Vz1	R2	Vz2
5k Ohms	500 Ohms	12V	166 Ohms	16V

Y (Volts)



$$gain = 6 = 1 + \frac{R_0}{1k} \Rightarrow R_0 = 5k\Omega$$

$$\left(\frac{R_1}{R_1+1k} \right)(6) = 2 \Rightarrow R_1 = 500\Omega$$

$$\left(\frac{R_{12}}{R_{12}+1k} \right)(6) = 0.667 \Rightarrow R_{12} = 125\Omega = R_1 \parallel R_2$$

$$R_2 = 166\Omega$$

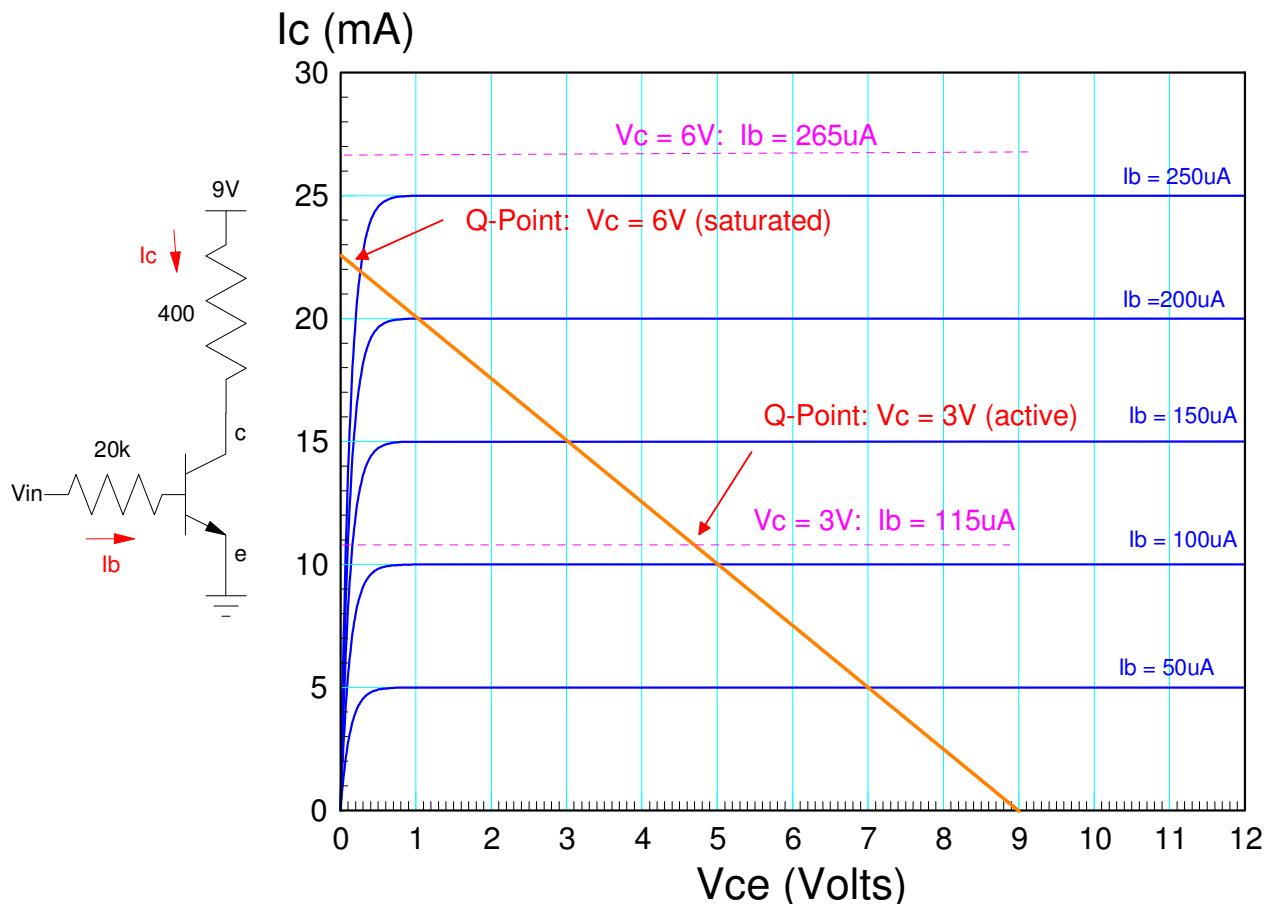
ECE 320 - Final (part 2) - Name _____

Semiconductors and Diode Circuits

Open-Book, Open Notes. Calculators & Matlab permitted. Individual Effort

- 1) Transistor Load Lines: Determine the gain of the following transistor (beta), the load line, and the Q point when V_{in} is 3V and 6V

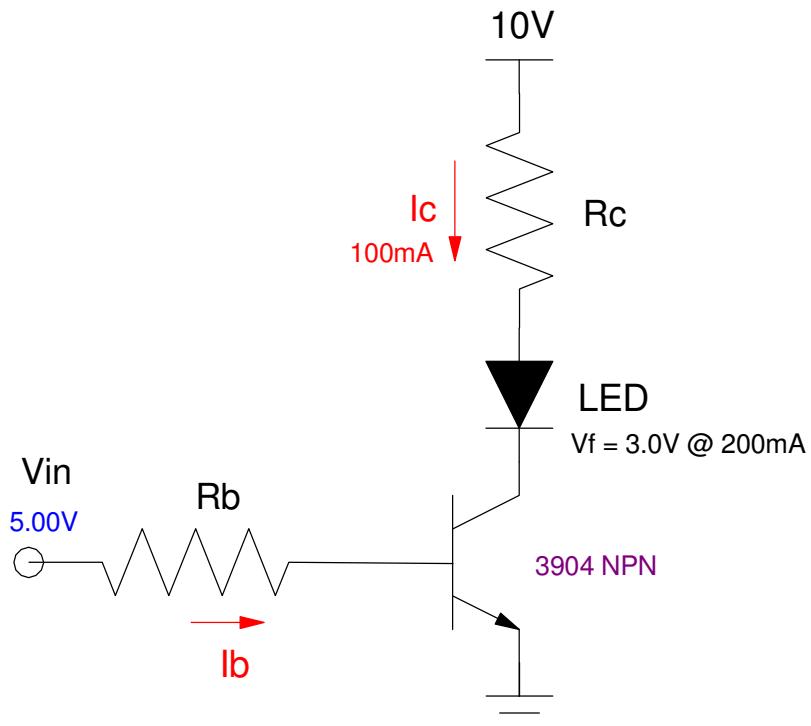
Load Line	Current Gain (beta)	Q point when $V_{in} = 3V$	Q-point when $V_{in} = 6V$
show on graph	100	show on graph	show on graph



2) Transistor Switch: Determine R_c and the range of R_b that results in $I_c = 100\text{mA}$ when $V_{in} = 5\text{V}$. Assume an ideal 3904 NPN transistor

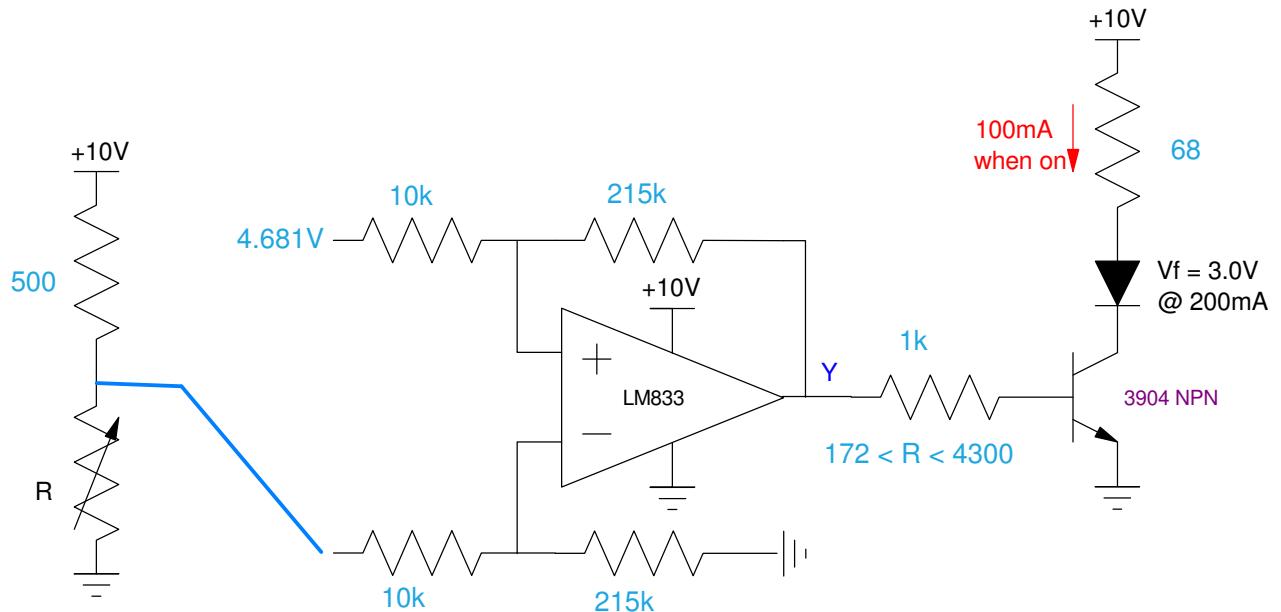
- $V_{be} = 0.7\text{V}$
- $V_{ce} = 0.2\text{V}$ when saturated
- $\beta = 100$

min value of R_b	max value of R_b	R_c so that $I_c = 100\text{mA}$
172 $I_b = 25\text{mA}$ (max value)	4300 $I_b = 1.00\text{mA}$	68 Ohms
215 $I_b = 20\text{mA}$ (max value)		
430 $I_b = 10\text{mA}$ (max value)		



3) Schmitt Trigger: Design a Schmitt Trigger so that

- The LED is on ($I_c = 100\text{mA}$) when $R < 440$,
- The LED is off ($I_c = 0\text{mA}$) when $R > 530$,
- No change (on or off) for $440 < R < 530$



$$R = 440 \quad (Y = 10\text{V})$$

$$\cdot \quad V_x = \left(\frac{440}{440+500} \right) 10\text{V} = 4.681\text{V}$$

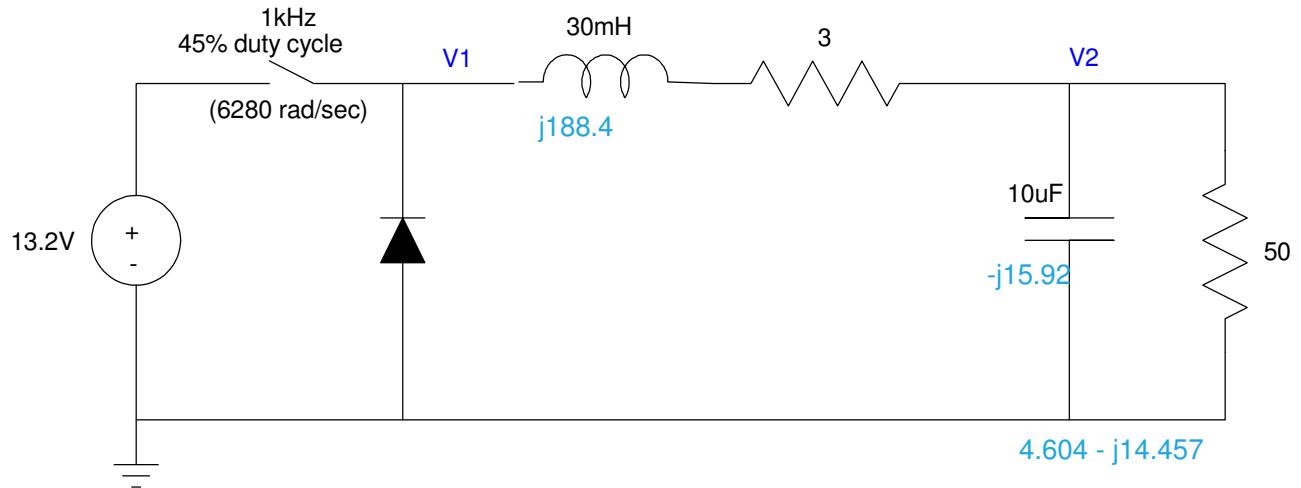
$$R = 530 \quad (Y = 0\text{V})$$

$$\cdot \quad V_x = \left(\frac{530}{530+500} \right) 10\text{V} = 5.146\text{V}$$

$$gain = \left(\frac{10\text{V}-0\text{V}}{5.146\text{V}-4.681\text{V}} \right) = 21.52$$

4) DC to DC Converter: Determine the voltages at V1 and V2 (both DC and AC)

V1		V2	
V1(DC)	V1pp (AC)	V2(DC)	V2pp (AC)
5.555V	13.9Vpp	5.241V	1.211Vpp



$$V_1(DC) = 0.45(13.2V) - 0.7(0.55) = 5.555V$$

$$V_2(DC) = \left(\frac{50}{50+3}\right) 5.555V = 5.241V$$

$$V_1(AC) = 13.9V_{pp}$$

$$V_2(AC) = \left(\frac{(4.604-j14.457)}{(4.604-j14.457)+(3+j188.4)}\right) (13.9V_{pp})$$

$$V_2(AC) = 1.211V_{pp}$$

5) MOSFET Switch: Determine I_{ds} and V_{ds} when $V_g = 5V$ and $V_g = 10V$. Assume

- $k_n = 150 \text{ mA/V}^2$
 - $V_{th} = 2.0V$ (turn-on voltage)

Vg = 5.0V		Vg = 10.0V	
Vds	Ids	Vds	Ids
4.60V	675mA	999.8mV	1.125A

$$V_g = 5V \text{ (saturated)}$$

$$I_{ds} = \frac{k_n}{2} (V_{gs} - V_{th})^2$$

$$I_{ds} = \frac{0.15}{2}(5 - 2)^2$$

$$I_{ds} = 0.675$$

$$V_{ds} = 10 - 8I_{ds}$$

$$V_{ds} = 4.60V$$

$V_g = 10V$ (ohmic)

$$I_{ds} = 0.15 \left(10 - 2 - \frac{V_{ds}}{2} \right) V_{ds}$$

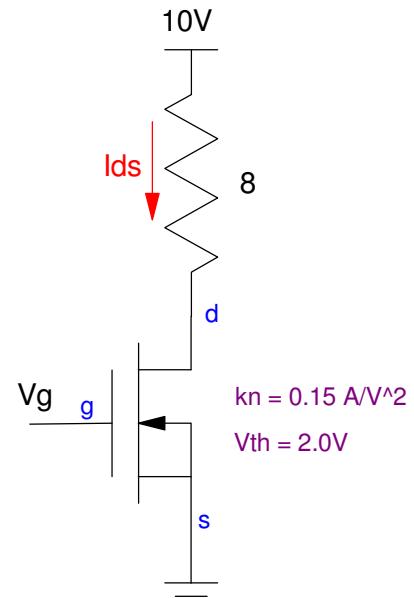
$$V_{ds} + 8I_{ds} = 10$$

the solution is

V_{ds} = 999.86mV

$$I_{DS} = 1.125$$

A



6) CMOS Logic. Design a circuit to implement $Y = A \text{ XOR } B$ using CMOS logic

Y(A,B)		B	
A	0	0	1
	1	1	0

$$\bar{Y} = AB + \bar{A}\bar{B}$$

$$Y = (\bar{A} + \bar{B})(A + B)$$

