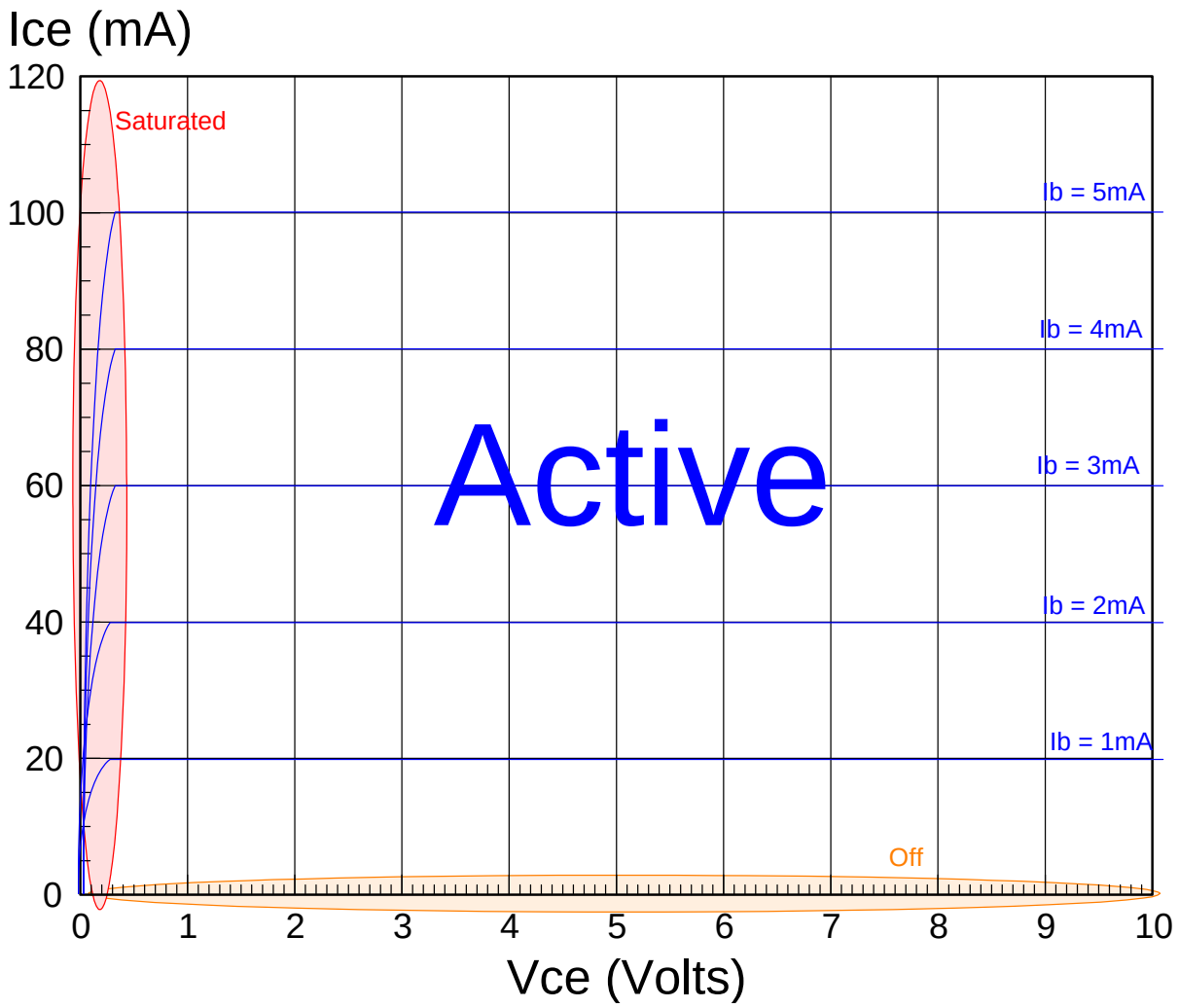
ECE 320 - Homework #5

Transistor Theory, Transistor Switch, H-Bridges. Due Monday, February 15th

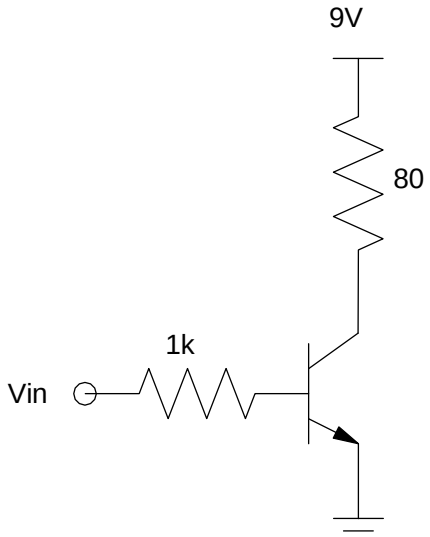
1) Assume the V/I characteristics for a transistor are as shown below.
   - Label the off / active / saturated regions
   - Determine the current gain, β

$$\beta = \frac{I_{ce}}{I_{be}} = \frac{100mA}{5mA} = 20$$



2) On the previous graph,

- Draw the load line for the following circuit
- Show on the graph the Q-point when



Vin = 0.1V

$I_b = 0$ (not enough votlage to turn on the diode)

Ic = 0

Q-Point: (Vce = 9V, Ice = 0mA)

Vin = 3.0V

$$I_b = \left(\frac{3V - 0.7V}{1k}\right) = 2.3mA$$

$$I_c = \beta I_b = 46mA$$

$$V_c = 9 - 80I_c = 5.32V$$

Q-Point: (Vce = 5.32V, Ice = 46mA)

Vin = 10.0V

$$I_b = \left(\frac{10V - 0.7V}{1k}\right) = 9.3mA$$

$$\beta I_b = 186mA$$

The maximum current is

$$\max(I_{ce}) = \frac{10V - 0.2V}{80\Omega} = 122.5mA$$

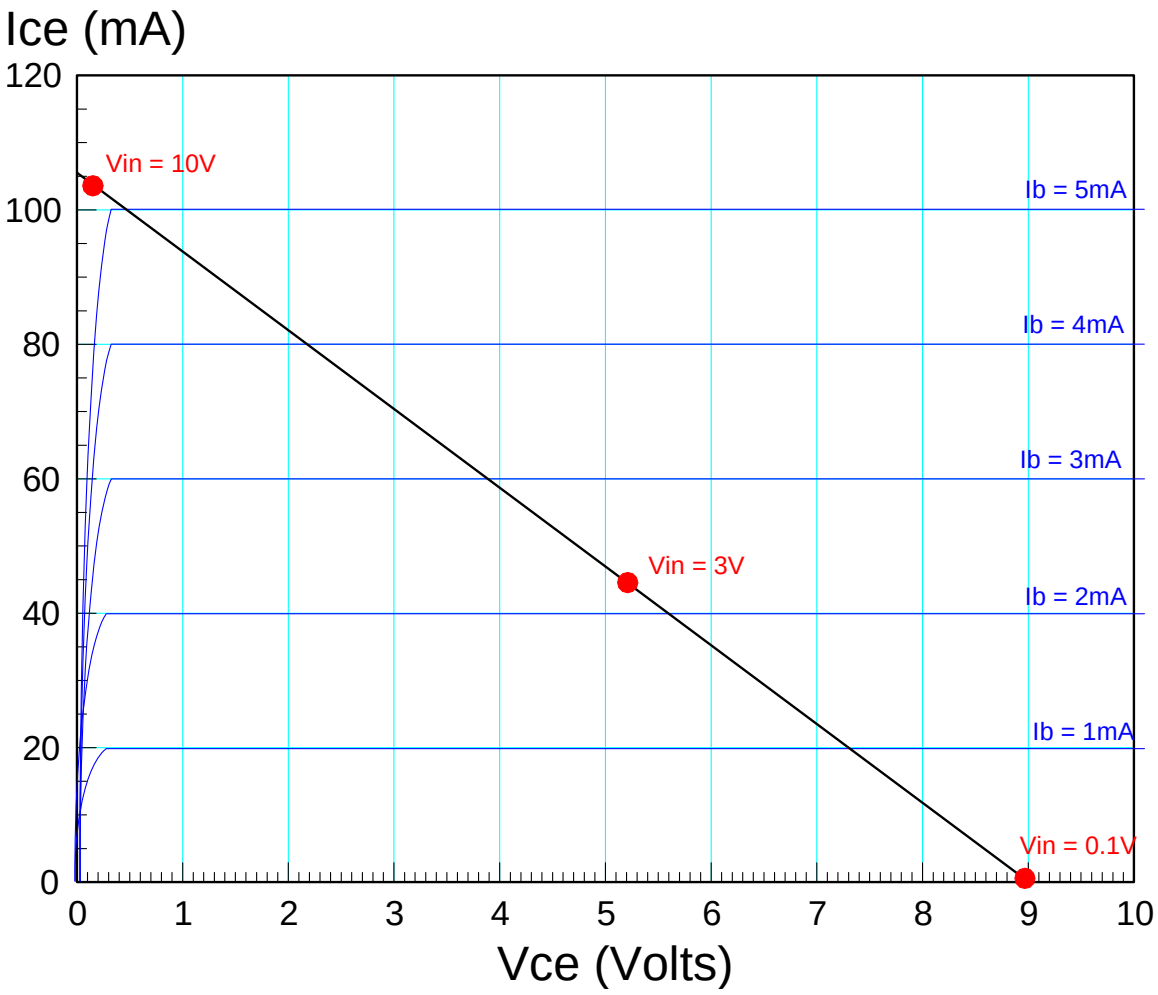
so this is saturated

$$\beta I_b > \max(I_c)$$

The Q-point is then

Vce = 0.2V

Ice = 122.5mA


Ice (mA)
120
100
80
60
40
20
0
Vin = 10V
Ib = 5mA
Ib = 4mA
Ib = 3mA
Vin = 3V
Ib = 2mA
Ib = 1mA
Vin = 0.1V
0
1
2
3
4
5
6
7
8
9
10
Vce (Volts)

Problem 3-7) Assume the following transistors

- NPN: 3904 $\beta = 100$, $I_{ce:\max} = 100mA$
- PNP: 3906 $\beta = 100$, $I_{ec:\max} = 100mA$

3) Transistor Switch: Design a circuit to allow your cell-phone to turn on and off a 3W white LED

- Input: 0V / 3.3V, capable of 5mA
- Output: 3W white LED, Vf = 3.1V @ 300mA
- Relationship:
  When the input is 3.3V, 100mA flows through the LED
  When the input is 0V, 0mA flows through the LED

For 100mA

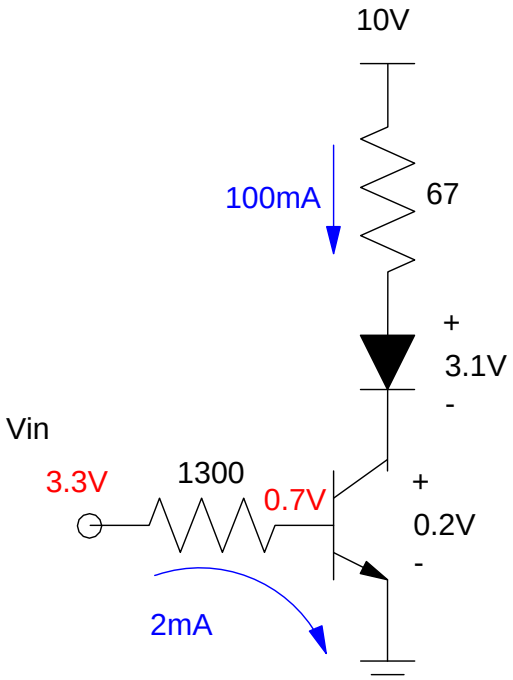
$$R_c = \left(\frac{10V - 3.1V - 0.2V}{100mA}\right) = 67\Omega$$

For Rb

$$I_b > \frac{I_c}{\beta} = 1mA$$

Let Ib = 2mA

$$R_b = \left(\frac{3.3V - 0.7V}{2mA}\right) = 1300\Omega$$



4) H-Bridge: Design a circuit to allow you to drive a DC motor forward and backwards

- Input: Four 0V / 10V signals, capable of driving 10mA
- Output: DC Motor which draws 100mA @ 10V
- Relationship: Depending upon the four inputs, drive the motor at { +10V, 0V, -10V }

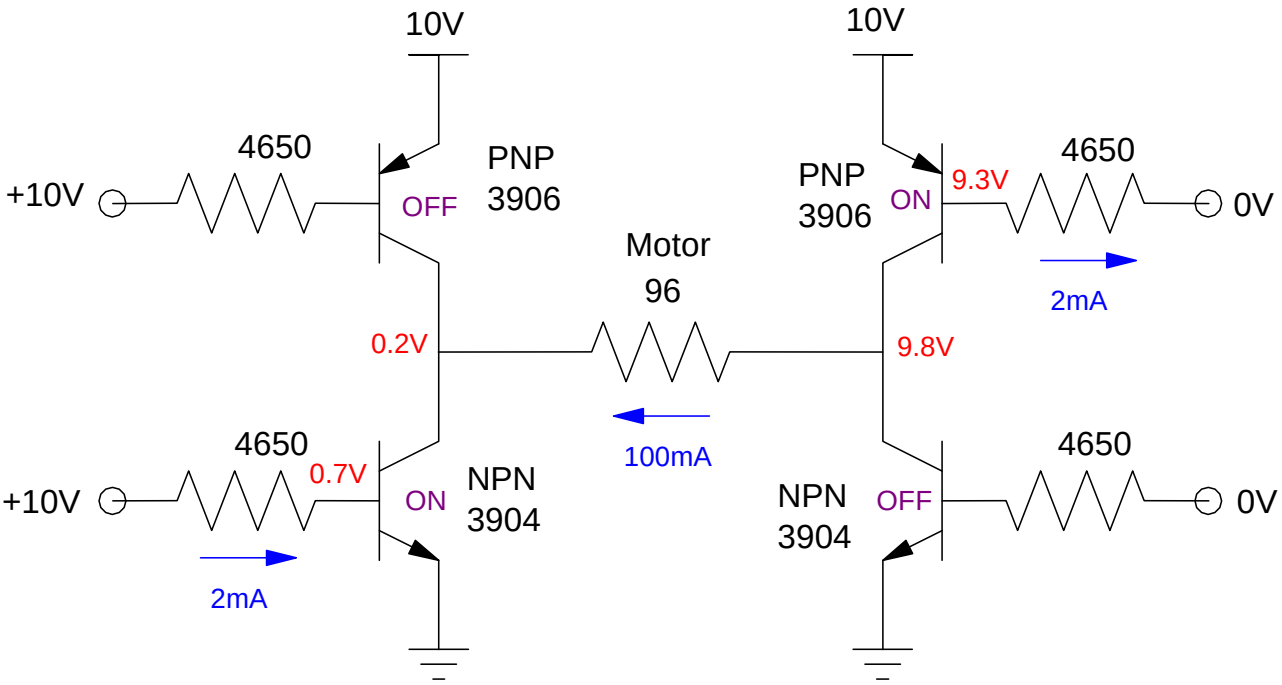
Ib:

$$I_b > \frac{I_c}{\beta} = \frac{100mA}{100} = 1mA$$

Let Ib = 2mA

Rb:

$$R_b = \left(\frac{10V - 0.7V}{2mA}\right) = 4650\Omega$$



5) Test: Simulate one of these circuits in PartSim (switch or H-bridge)

6) Validation: Build one of these circuits and verify it's operation in lab.

Bonus! 1 point bonus on your final grade in ECE 320.

Make a short (1 - 3 minute) video where you

- Intruduce yourselves
- Present the requirements for your circuit
- Show the schematic and explain your analysis (keep it short)
- Show your simulation results (keep it short)
- Demonstrate that your circuit works