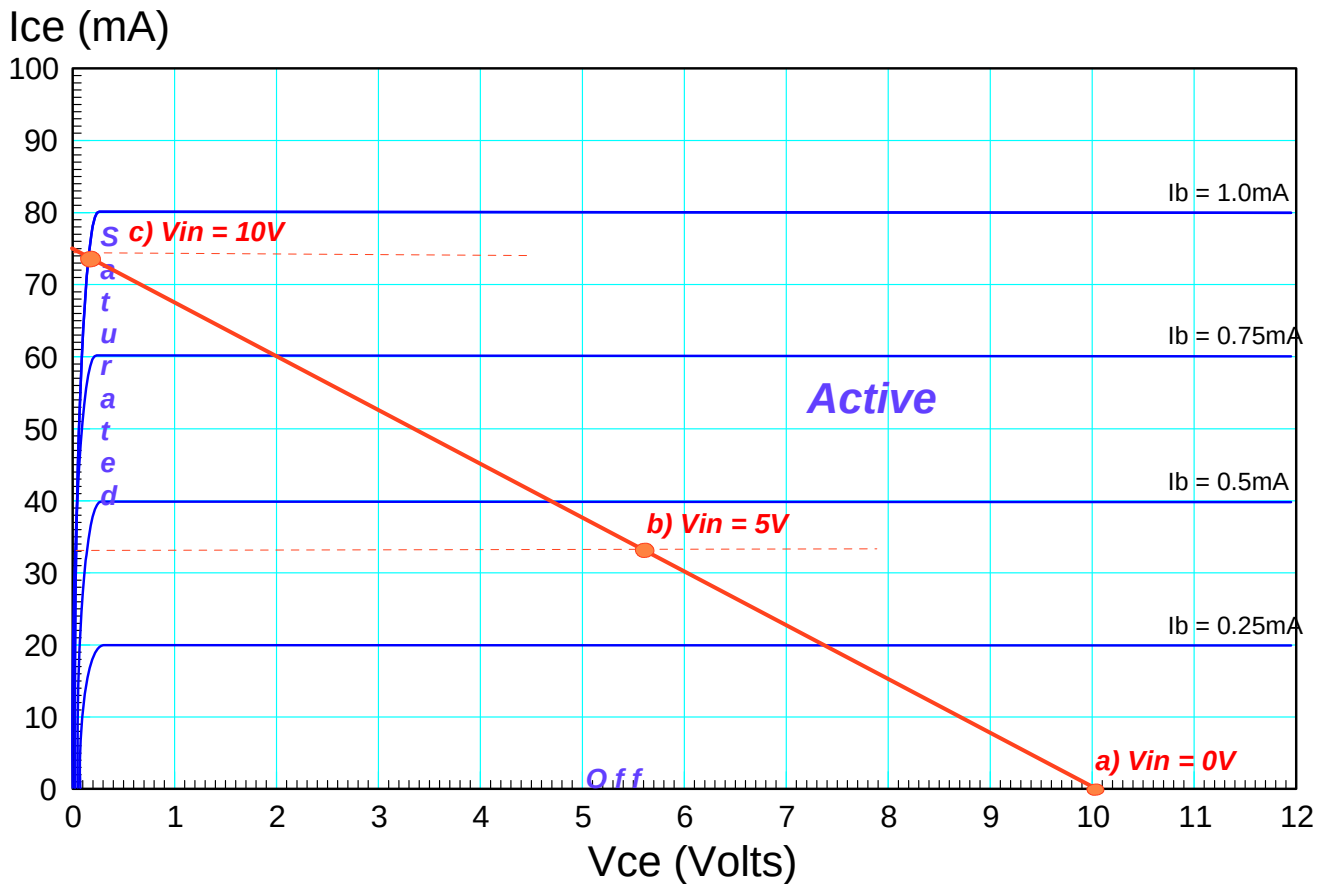
ECE 320 - Solution to Homework #5

Transistor Theory, Transistors used as a Switch, H-Bridge Due Monday, September 24th, 2018

1) The VI characteristics for a transistor are shown below:

- What is the current gain, β? **80**
- Label the Off / Saturated / Active regions. **shown on graph**



2) Draw the load line for the following circuit. Mark on the load line the operating point (termed Q-point) when

Vin = 0V

$$I_b = 0$$

Vin = 5V

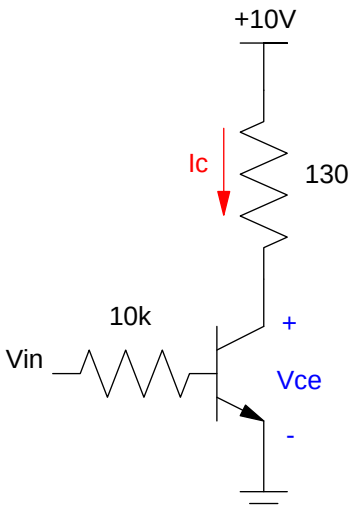
$$I_b = \left(\frac{5V - 0.7V}{10k}\right) = 0.43mA$$

$$\beta I_b = 34.4mA \qquad V_{ce} = 10 - 130I_c = 5.528V$$

Vin = 10V

$$I_b = \left(\frac{10V - 0.7V}{10k}\right) = 0.93mA$$

$$\beta I_b = 74.4mA \quad V_{ce} = 10 - 130I_c = 0.328V$$



Problem 3-6: Assume a LM833 transistor (NPN) and LM837 (PNP) ($0.04 each)

- $\beta = 100$
- $|V_{ce:sat}| = 0.2V$
- $\max(I_c) = 200mA$

3) Design a circuit to meet the following requirements (i.e. a transistor used as a switch)

- Input: 0V / 5V binary signal capable of 20mA
- Output: DC Motor which draws 200mA @ 10V
- Relationship:
  - When Vin = 0V, 0V is applied to the motor
  - When Vin = 5V, 10V is applied to the motor +/- 1V

$I_c = 200mA$ (nothing to calculate - that's just how much the motor draws at 10V)

$$R_{motor} = \left(\frac{10V}{200mA}\right) = 50\Omega$$

To saturate the transistor

$$\beta I_b > I_c$$

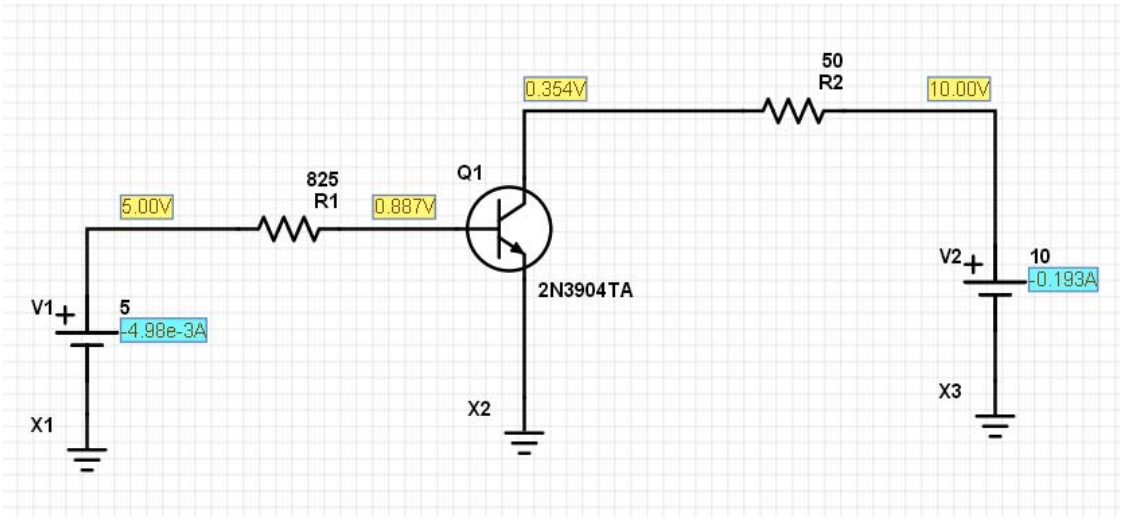
$$I_b > \frac{200mA}{100} = 2mA$$

Let Ib = 4mA

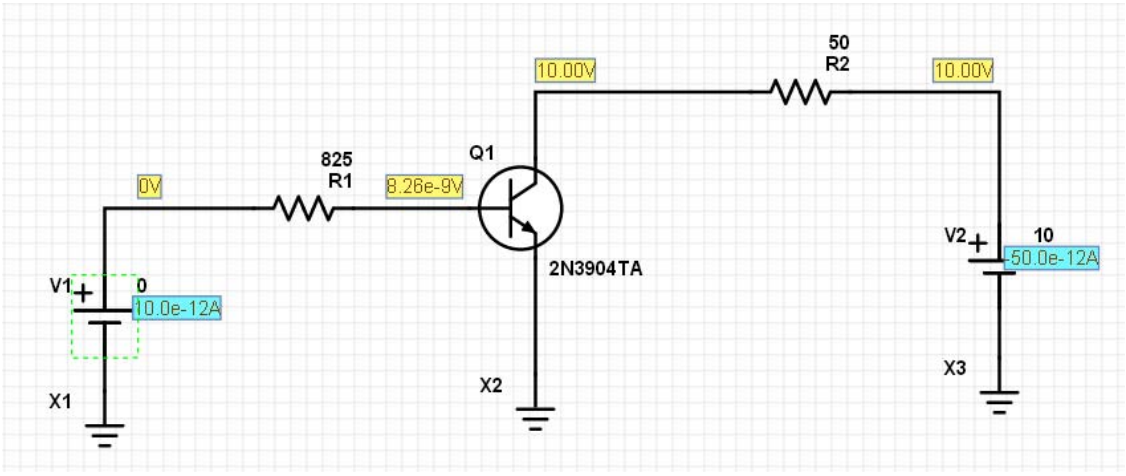
$$R_b = \left(\frac{5V - 0.7V}{4mA}\right) = 825\Omega$$

4) Check your design in PartSim

Motor On: Vin = 5V



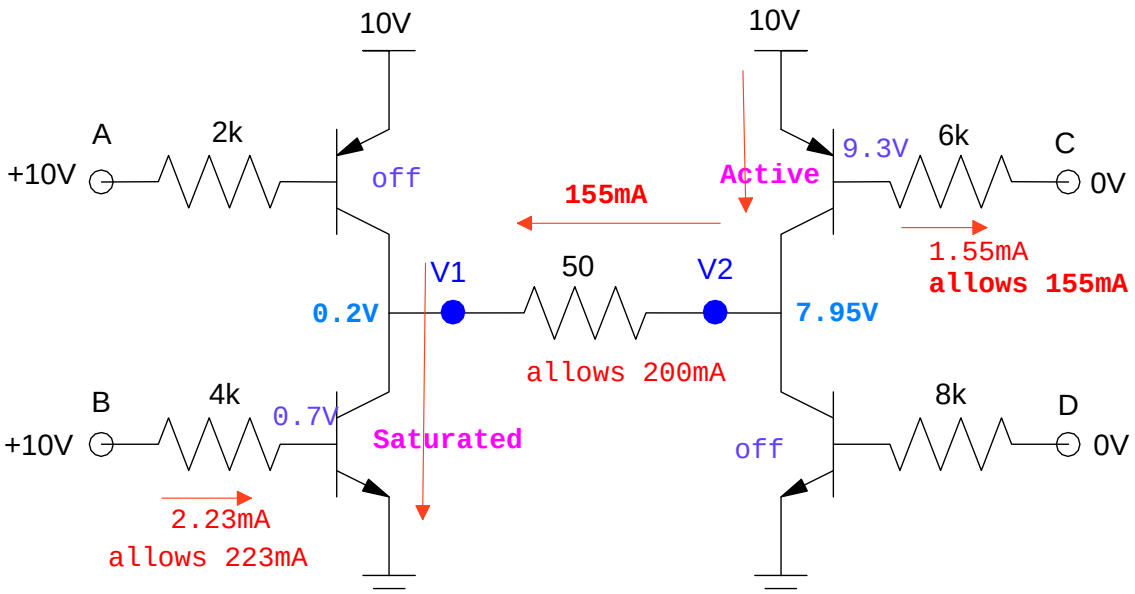
Motor Off (Vin = 0V)



	On			Off		
	Calculated (prob 3)	Simulated (prob 4)	Measured (prob 5)	Calculated (prob 3)	Simulated (prob 4)	Measured (prob 5)
Vb	0.7V	0.887V		0V	8nV	
Ib	4mA	4.98mA		0mA	10pA	
Vce	0.2V	0.354V		10V	10V	
Ic	196mA	198mA		0mA	50pA	

5) Chck your design in lab.

6) Determine the voltages V1 and V2 for the following H-bridge



Problem 6 & 7

First, find which transistors are on and which are off.

Next, find the base currents:

B: $I_b = \left(\frac{10V - 0.7V}{4k}\right) = 2.23mA$

$\beta I_b = 223mA$

C: $I_b = \left(\frac{10V - 0.7V}{6k}\right) = 1.55mA$

$\beta I_b = 155mA$

Load:

$\left(\frac{10V}{50\Omega}\right) = 200mA$

The smallest current wins (limits the overall current)

$I = 155mA$

7) Modify this circuit to meet the following requirements

- Input: A,B,C,D. 0/10V binary signals, capable of 20mA
- Output: 50 Ohm resistor
- Relationship: By varying A,B,C,D, the voltage across the 50 Ohm resistor can be set to +10V, -10V, and 0V (+/- 1V)

The current you want is

$$I = \left(\frac{10V}{50\Omega}\right) = 200mA$$

To saturate the transistors

$$\beta I_b > I_c$$

$$I_b > \frac{200mA}{100} = 2mA$$

Let

$$I_b = 4mA$$

$$R_b = \left(\frac{10V - 0.7V}{4mA}\right) = 2325\Omega$$

Let Rb = 2200 Ohms