

# ECE 320 - Homework #5

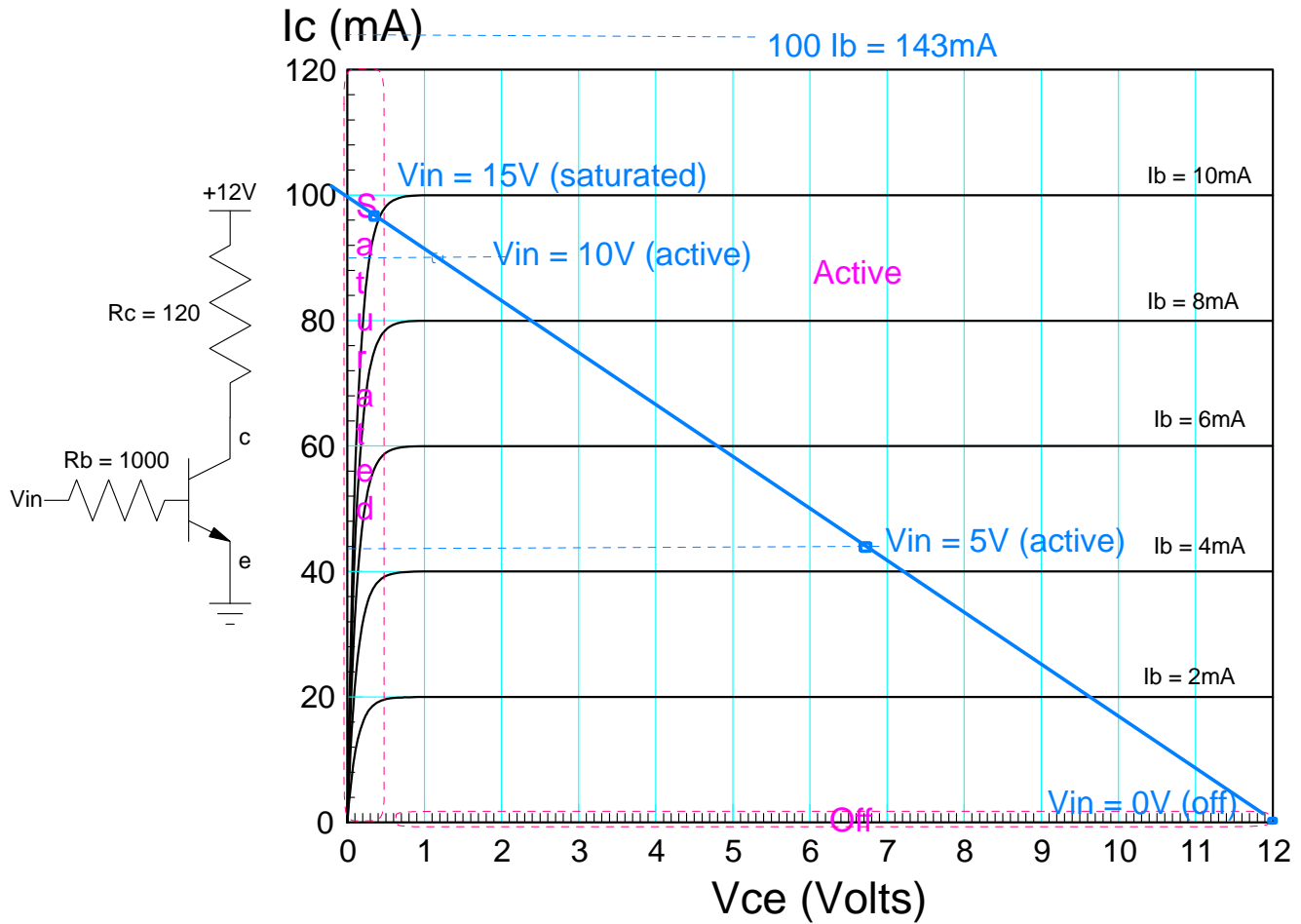
Transistor Theory, Transistors used as a Switch Due Monday, September 30th

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

- What is the current gain,  $\beta$ ? **10**
- Label the Off / Saturated / Active regions.

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

$V_{in}$	0V	5V	10V	15V
$I_b = (V_{in} - 0.7)/1k$	0 mA	4.3 mA	9.3 mA	14.3 mA
$I_c = 10I_b$	0 mA	43 mA	93 mA	98.3 mA
$V_{ce} = 12 - 120 I_c$	12 V	6.84 V	0.84 V	0.2 V
	off	active	active	saturated



Problem 3-6: Assume a TIP112 transistor (NPN) (\$0.41 each)

- $\beta = 1000$
- $|V_{ce:sat}| = 0.9V$
- $\max(I_c) = 4A$
- $V_{be} = 1.4V$

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  $V_{in} = 0V$ , 0V is applied to the motor
  - When  $V_{in} = 5V$ , 10V is applied to the motor +/- 1V

Collector Side: Just connect the motor from +10V to the collector. You don't need to add anything else.

Base: The current you need is

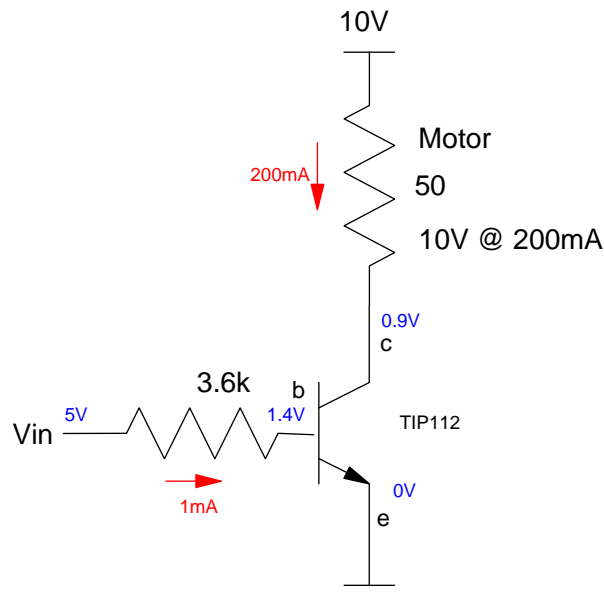
$$\beta I_b > I_c$$

$$I_b > \frac{200mA}{1000} = 0.2mA$$

Let  $I_b = 1mA$

$$R_b = \left( \frac{5V - 1.4V}{1mA} \right) = 3.6k\Omega$$

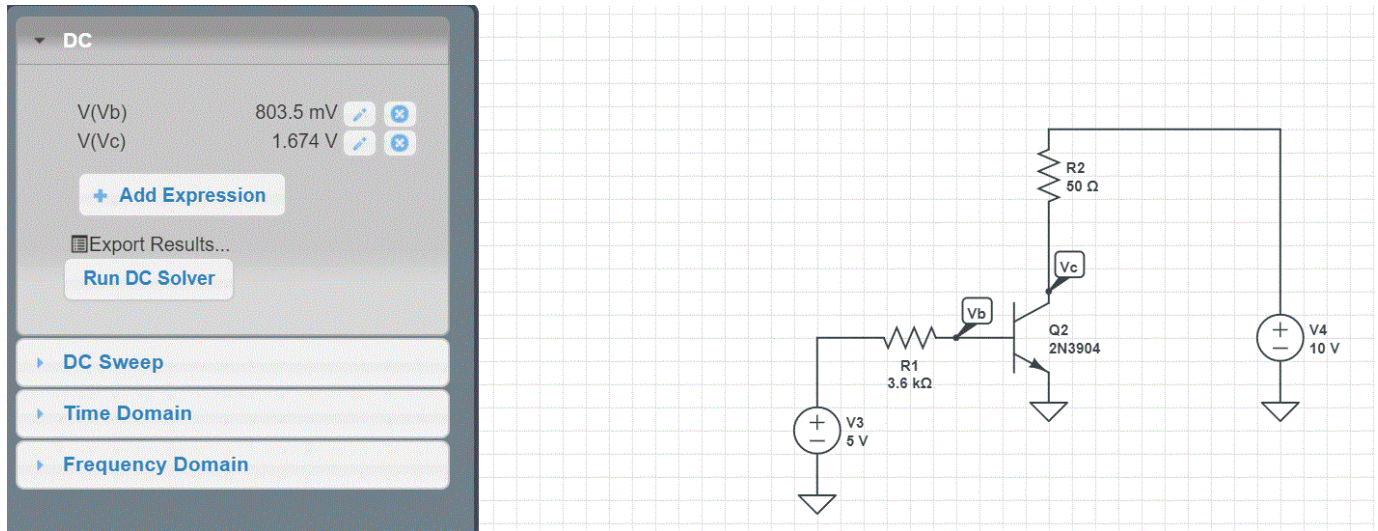
( 1k also works )



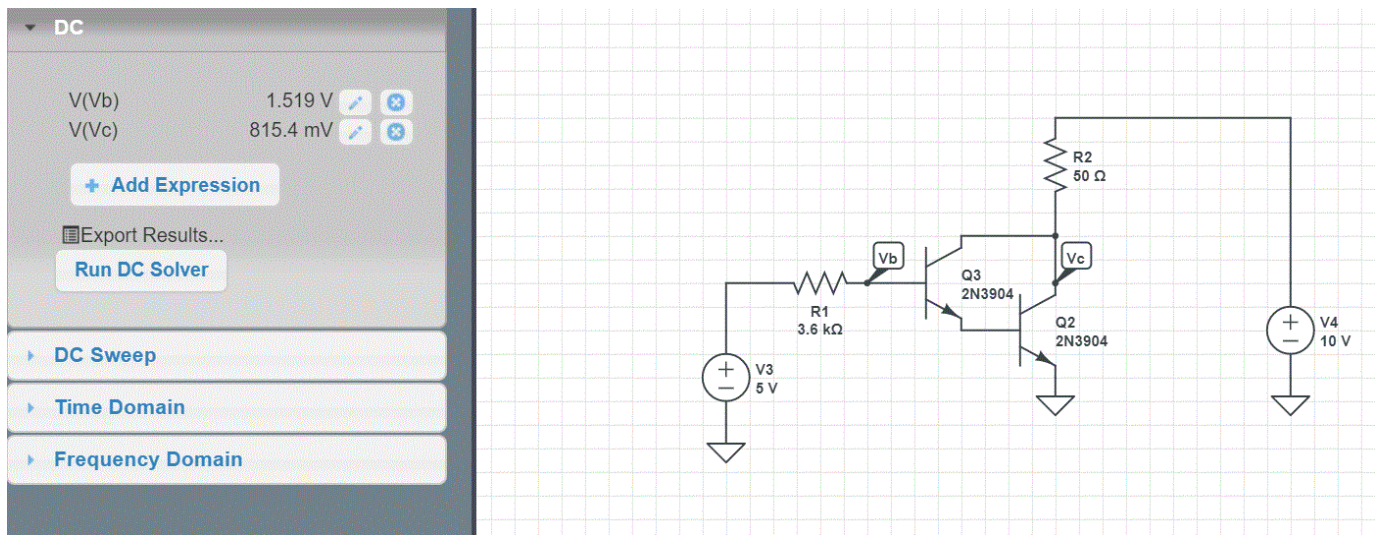
#### 4) Check your design in PartSim

note:

- Use a 50 Ohm resistor to model the motor ( 200mA @ 10V )
- Use a 3904 transistor ( Vendor Parts - Fairchild - NPN - 3904 )



The gain of a 3904 transistor is only 200. This results in the transistor being in the active mode ( $V_{ce} > 0.2V$ ). If you use two transistors as a Darlington pair, the gain becomes 2002



#### 5) Lab

	$V_{in}$	$V_{be}$	$V_{ce}$
Calculated	5.0 V	1.4 V	0.9 V
Simulated	5.0 V	1.519 V	0.815 V
Measured	5.0 V	1.39 V	0.68 V