BJT IV Characteristics

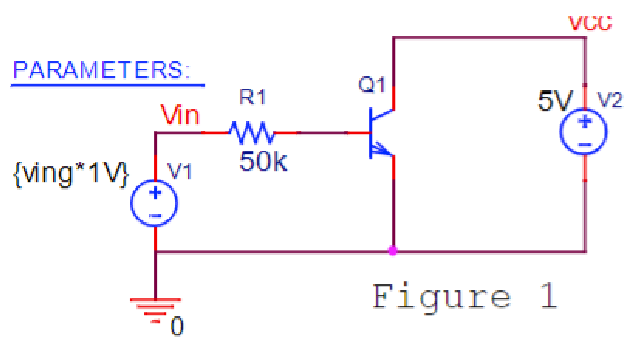
Contents

Executive Summary: This experiment validates the function of a bipolar junction transistor and its different terminals.

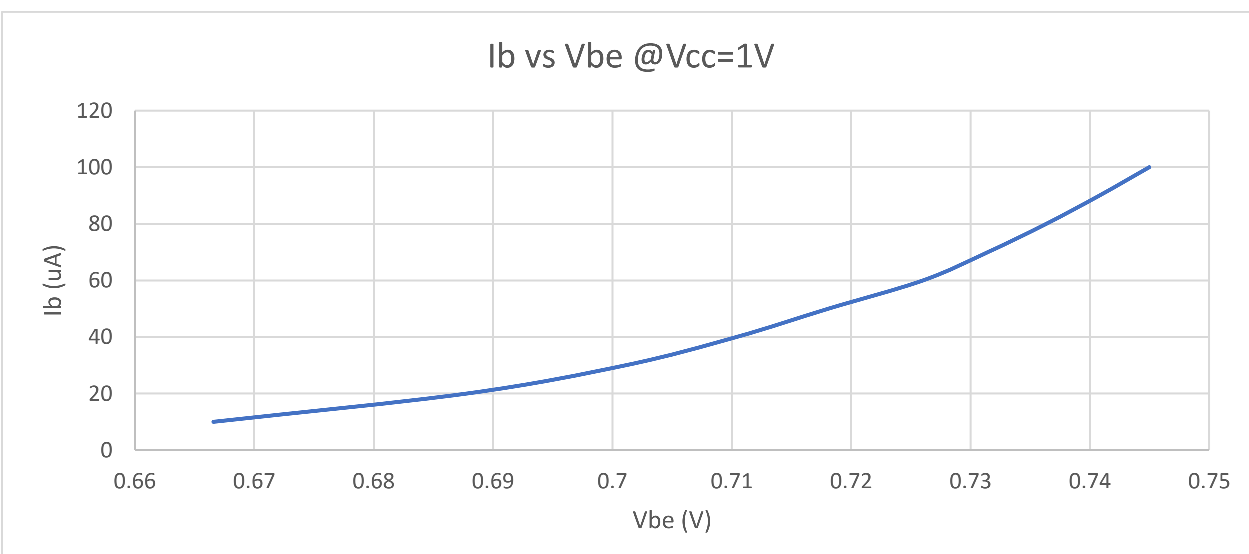
Objective: To study the current voltage relationship of bipolar junction transistors in both a laboratory and simulation setting.

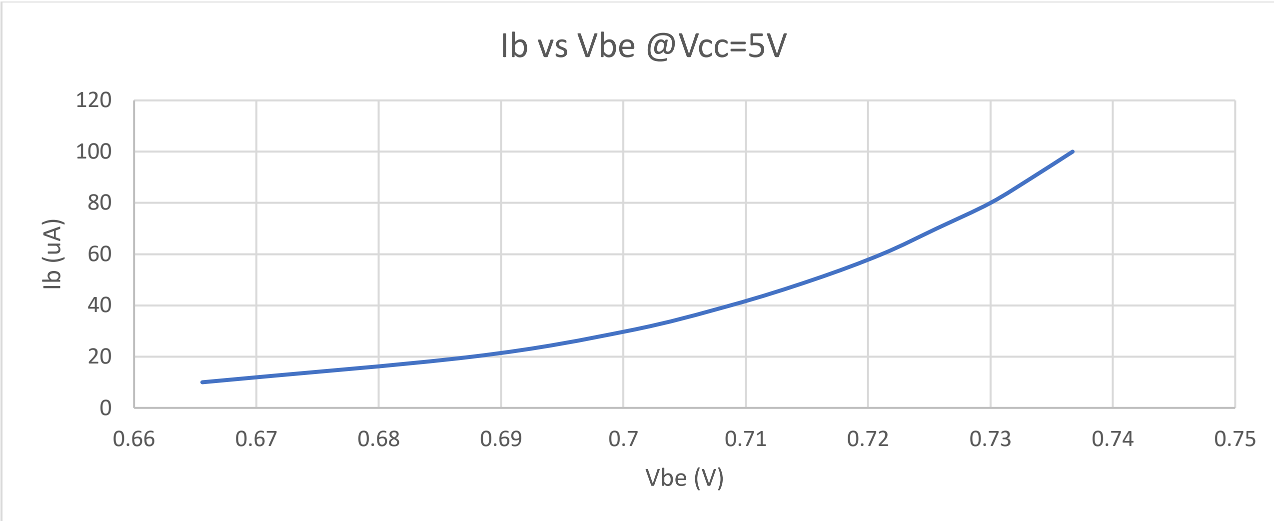
Figure 1 (LAB)

Schematic



Excel Generated Plot

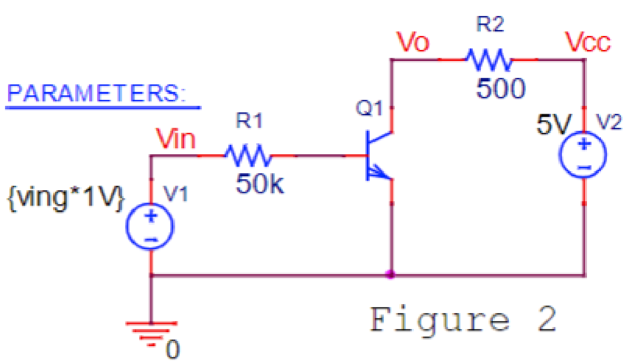




This is the input configuration curve. So between Vcc = 1V and 5V (which is close to output voltage Vce), there is a small change in input voltage Vbe while input current Ib is more or less constant, indicating that Vbe is dependent on Vcc or Ic. This aligns with theory: Ic = Is exp(Vbe/Vt) shows that collector (output) current is voltage controlled via Vbe.

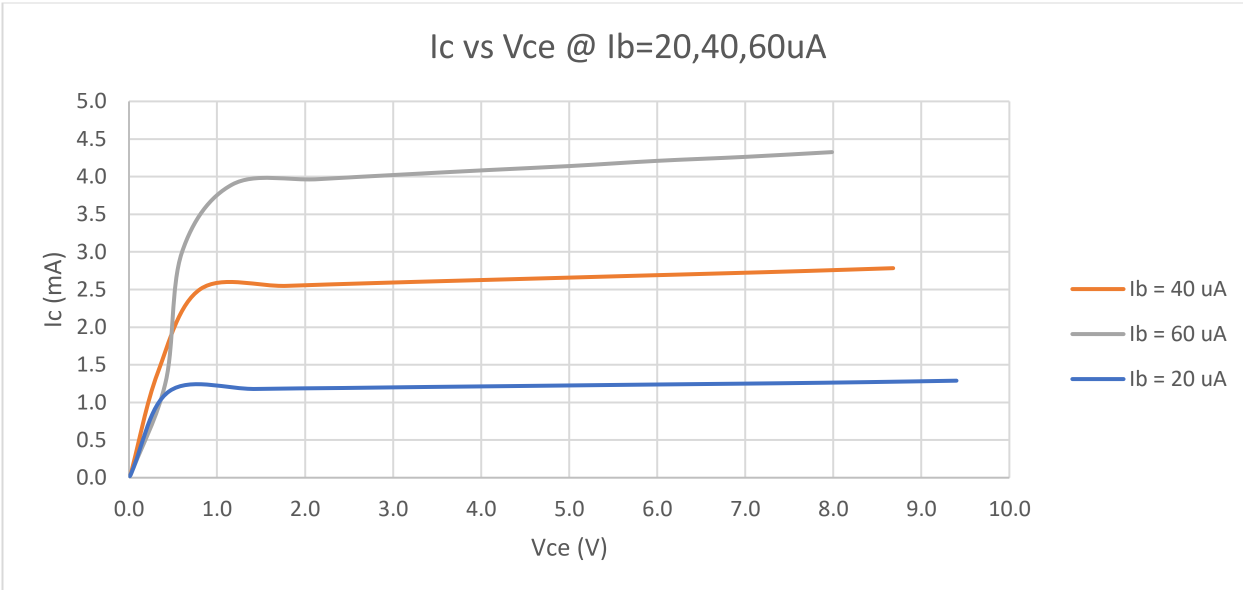
Figure 2 (LAB)

Schematic



Excel Generated Plot

This is the output configuration curve.



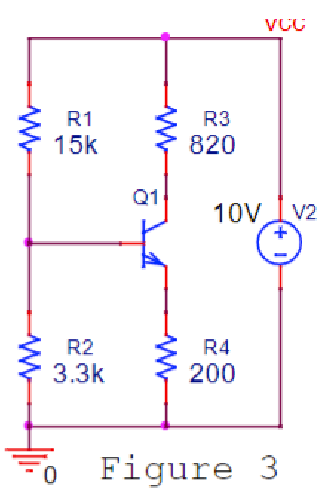
BETA Calculation

At Vce = 5V, Ib = 40uA, Ic = 2.6mA, so by Ic = βIb, β will be

β = 65.

Figure 3 (LAB)

Schematic



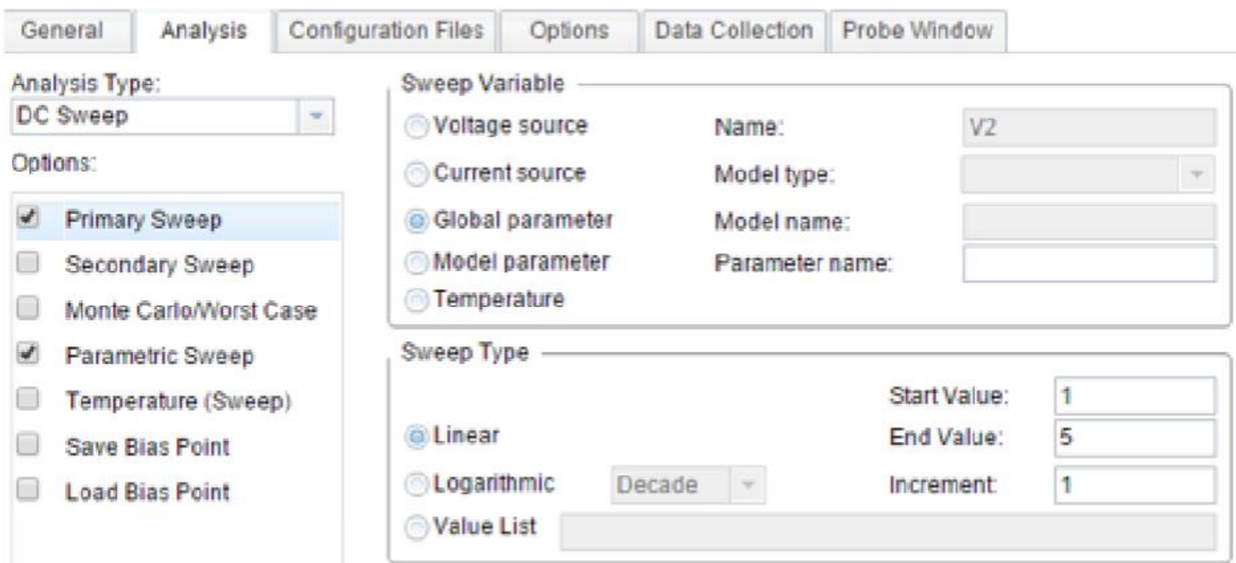
R differences	Vc	Ve	Vce [V]	Ib [mA]	Ic [mA]	gain (beta)
R1=14.7k	7	1.2	5.8	0.06481	4.684	72.2728
R3=680						

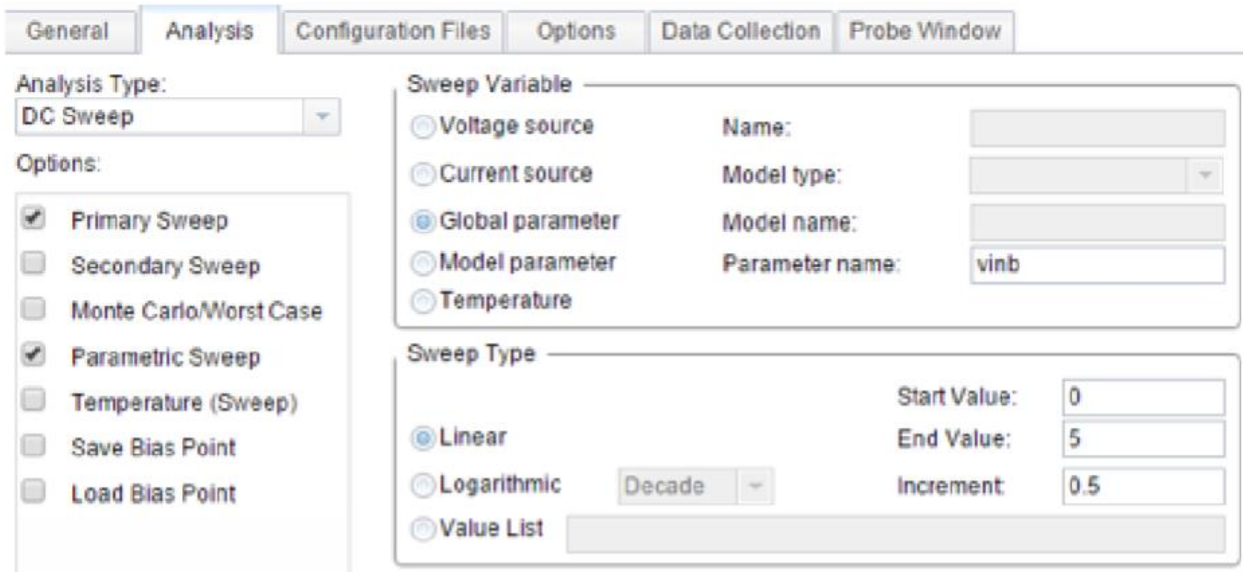
Betas for figures 2 and 3 are similar in magnitude 65 vs 72.

Figure 1 (SIM)

Schematic same as in lab portion of this report.

Simulation Profile





Excel Generated Plot

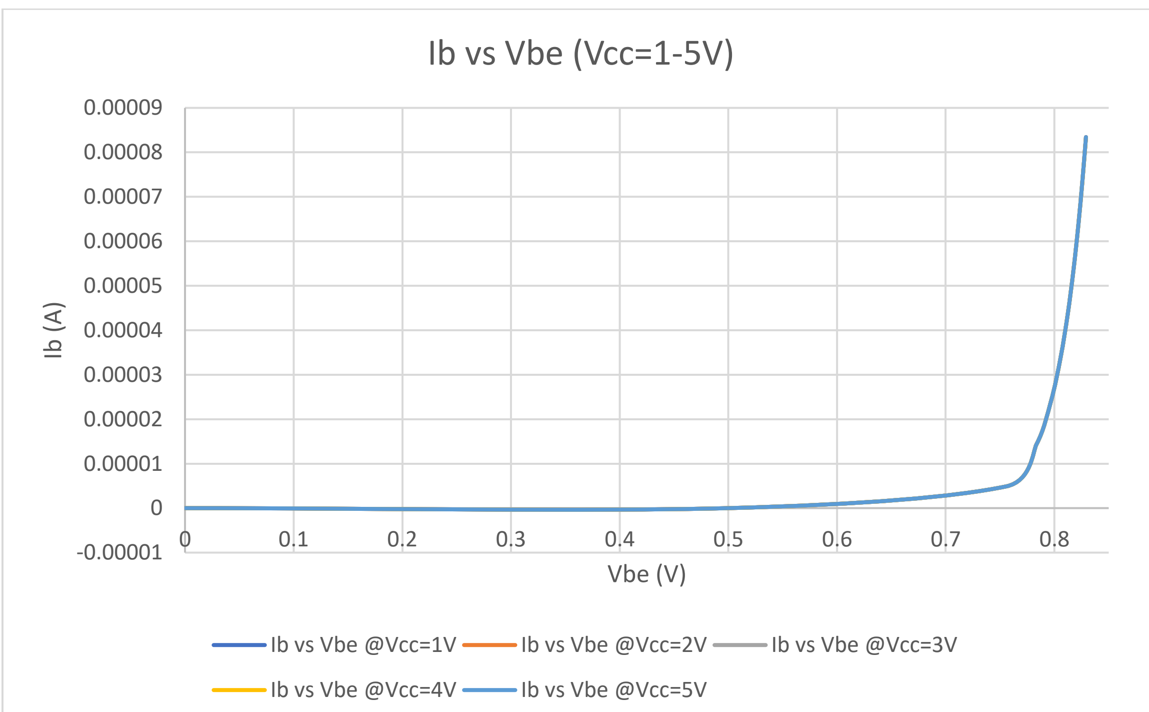
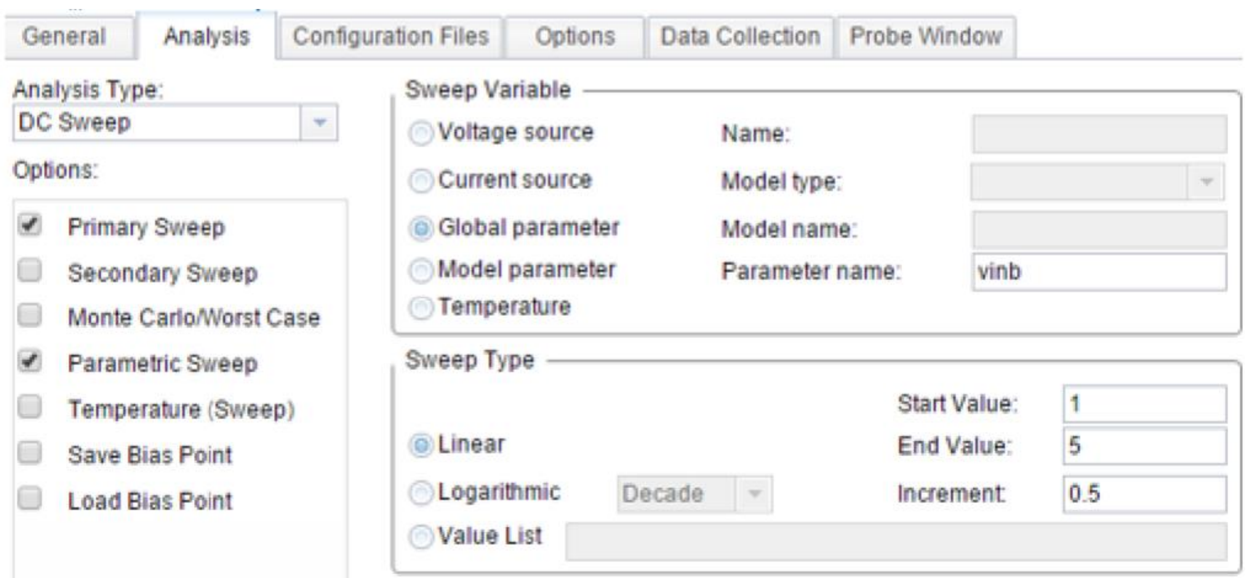
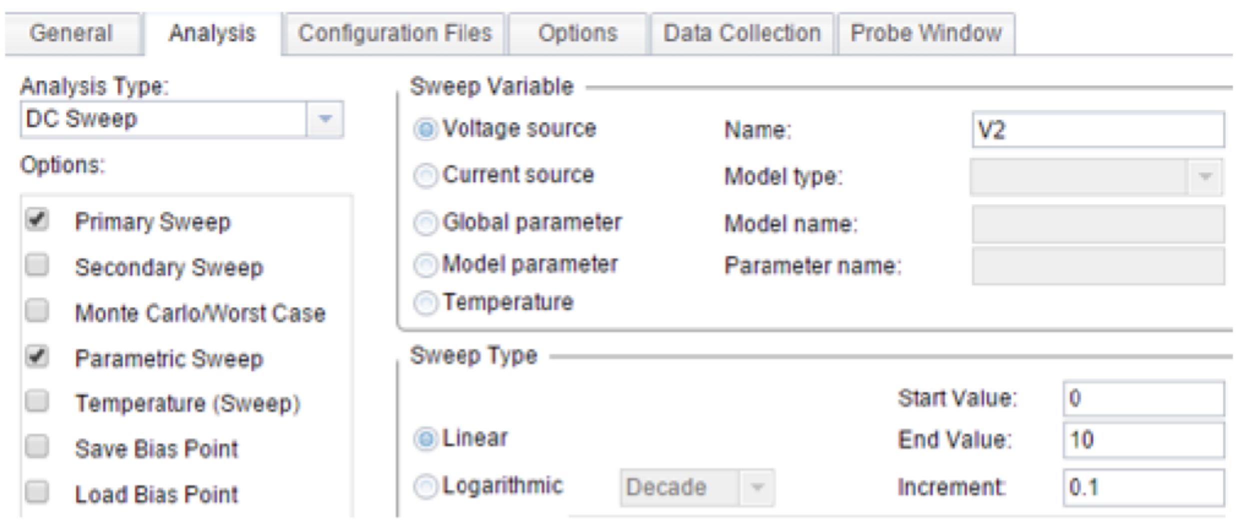


Figure 2 (SIM)

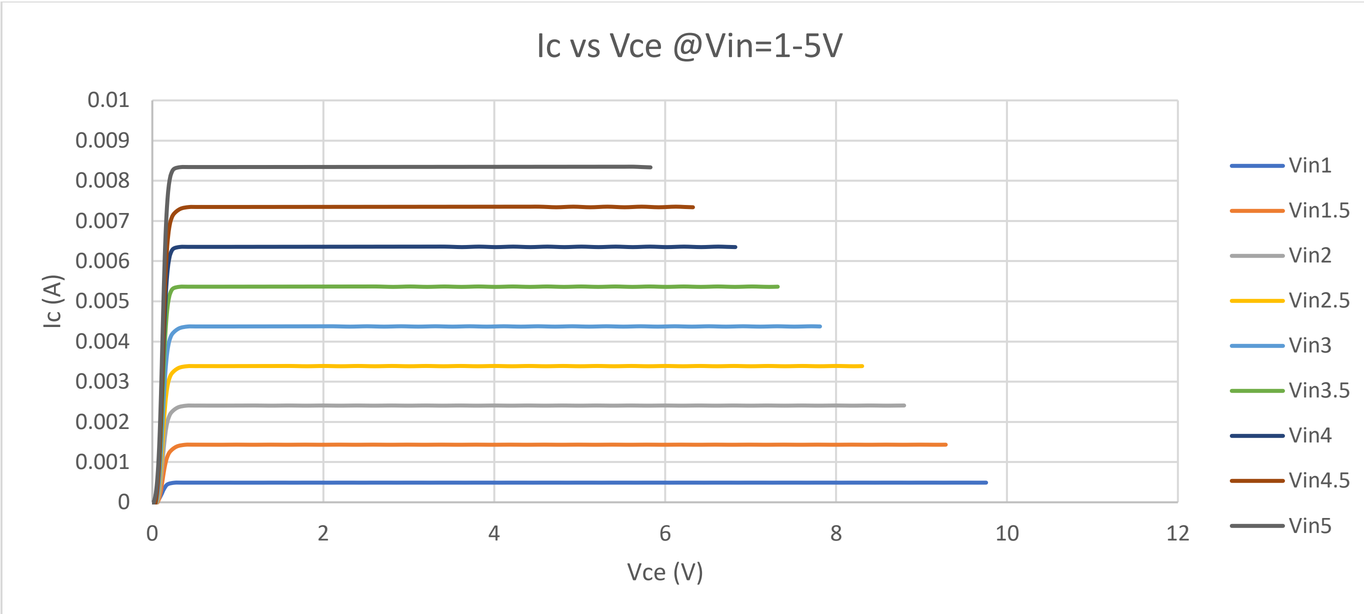
Schematic same as in lab portion of this report.

Simulation Profile





Excel Generated Plot

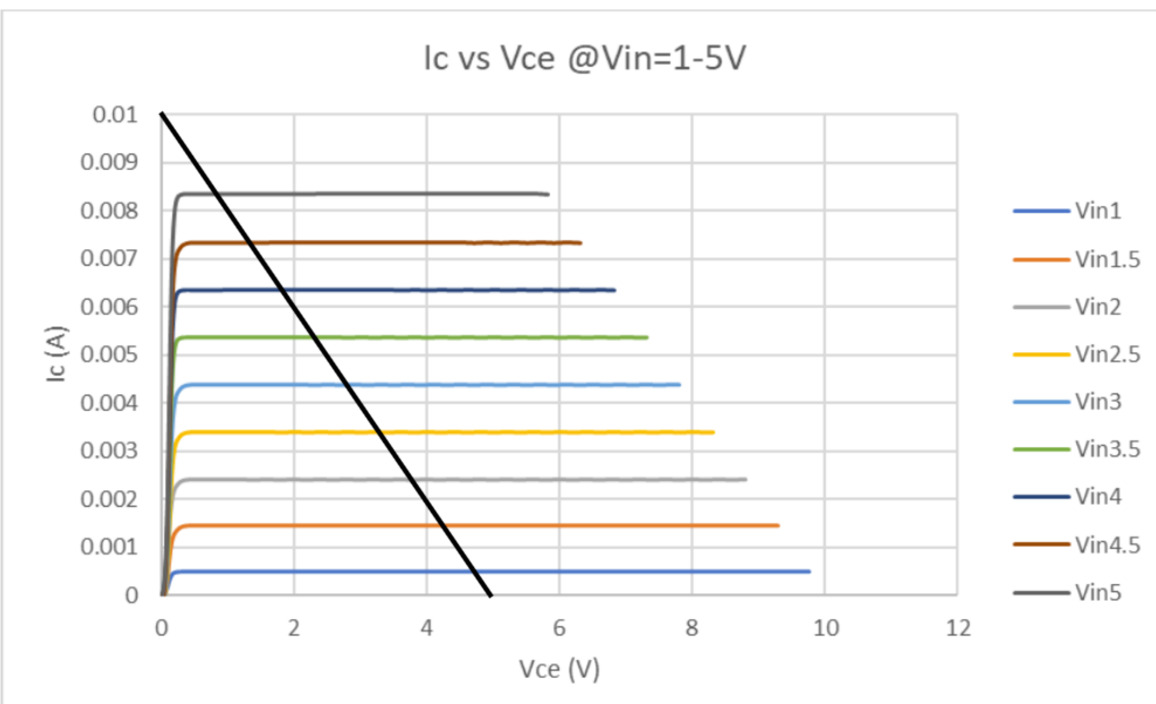


As Vin (and therefore input voltage Vb) increases, Ic increases and Vce decreases. Vb's increase corresponds to Vbe's increase, so the Ic = Is exp(Vbe/Vt) relationship is maintained.

1. Load Line

   Y intercept is Vcc/R = 5V/500ohm = 10mA.

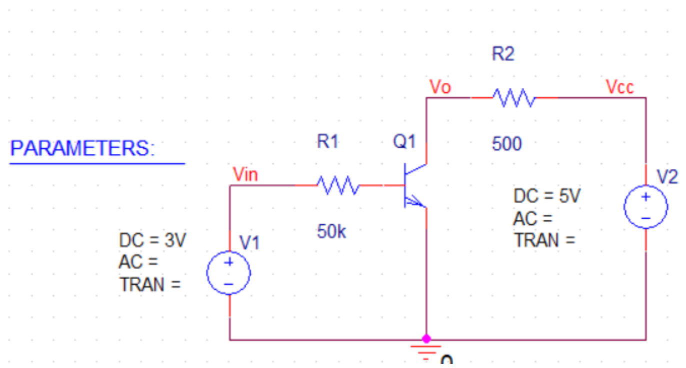
   X intercept is Vce (Vo) = 5V /// slope = -1/500ohm

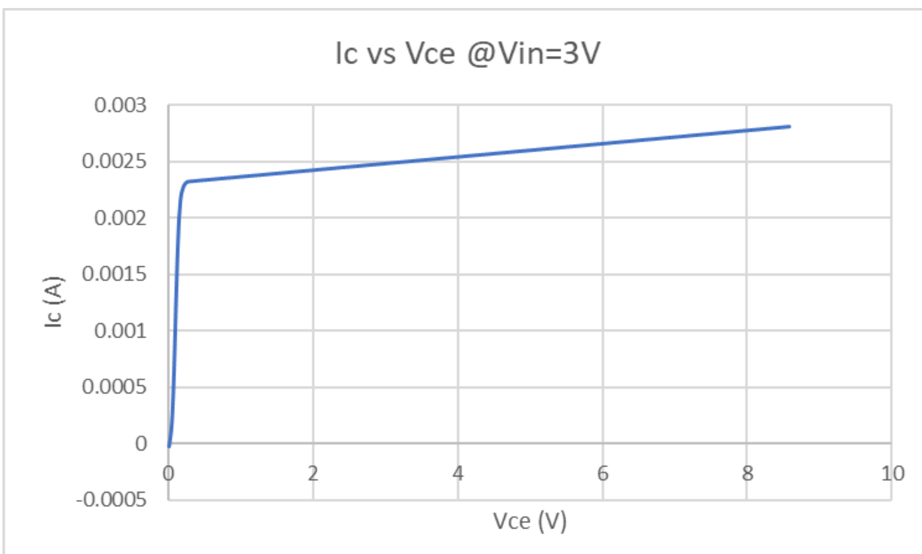


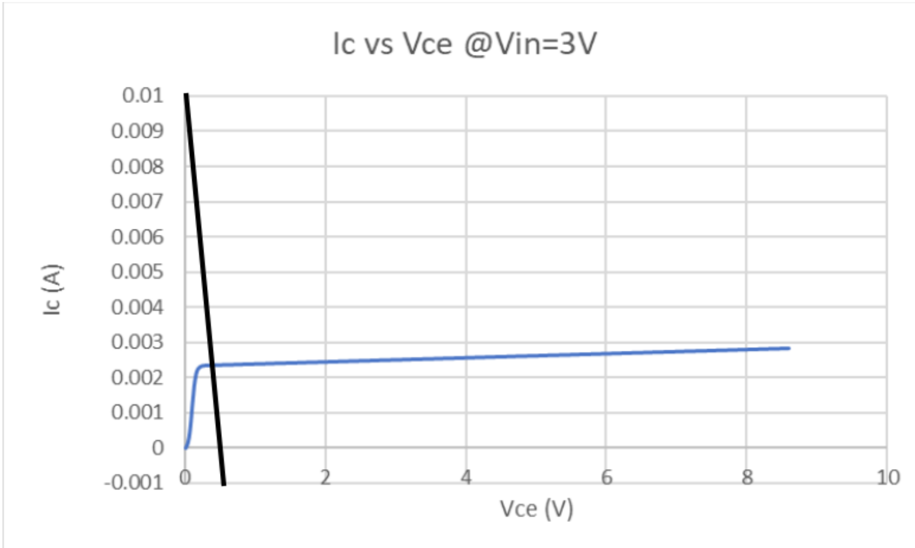
2. At Vin=3V, Vo (Vce) = 2.9V & Ic = 4.4 mA. This is the operating point (Qpoint).
3. If Vbe = 0.812V @ the Qpoint (Vce = 2.9V, Ic = 4.4mA, Vin = 3V), then what is Beta?

   Vb = Vbe because emitter is grounded, so Ib = Vb/R1 = 0.812/50k =16.24uA.

   Now Ic=βIb gives β=270.94.
4. If Vin = 3V, Va = 50V (aka -50V), then Vo (Vce) = 2.9V, Ic = Ic_0(1+Vce/Va) = 46.552mA. Transistor is in forward active.
5. Schematic (@ Beta = 50)





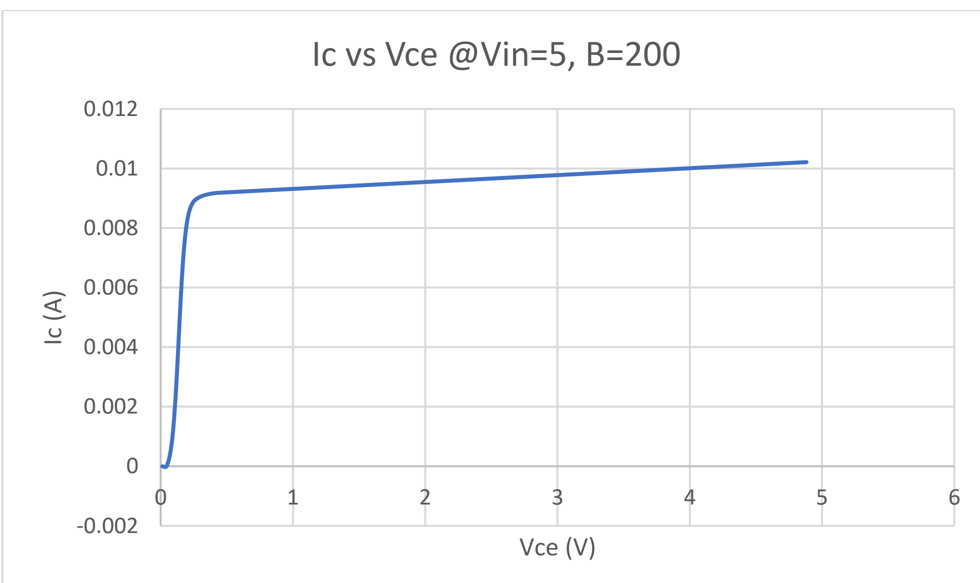


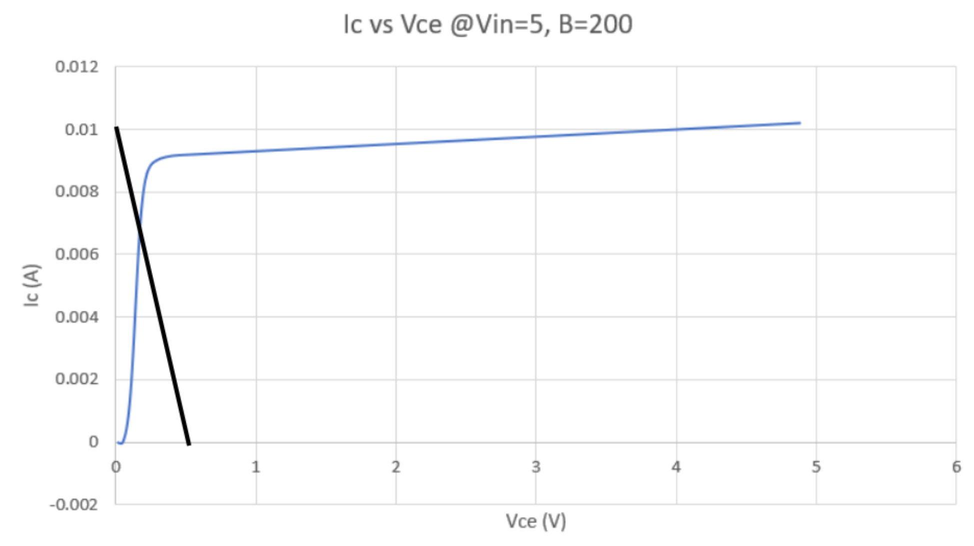
Qpoint is at Vo (Vce) = 0.4V, Ic =2.5mA, transistor is in forward active mode.

Y intercept = Vcc/R = 10mA.

X intercept = Ic = -Vce/500 + 10mA, solving for Vce when Ic = 0 gives 0.55V.

Now @ Beta=200





1. Qpoint is at Vo (Vce) = 0.25V, Ic =7mA, transistor is in saturation mode.

Y intercept = Vcc/R = 10mA.

X intercept = Ic = -Vce/500 + 10mA, solving for Vce when Ic = 0 gives 0.55V.

2. Now, (still in B=200 case) if Vo = 4V, what is the new value of R2 @Vin=3V?

   Ic = 10mA, R2 = (Vcc-Vo)/Ic = (5-4)/10mA = 100 ohm

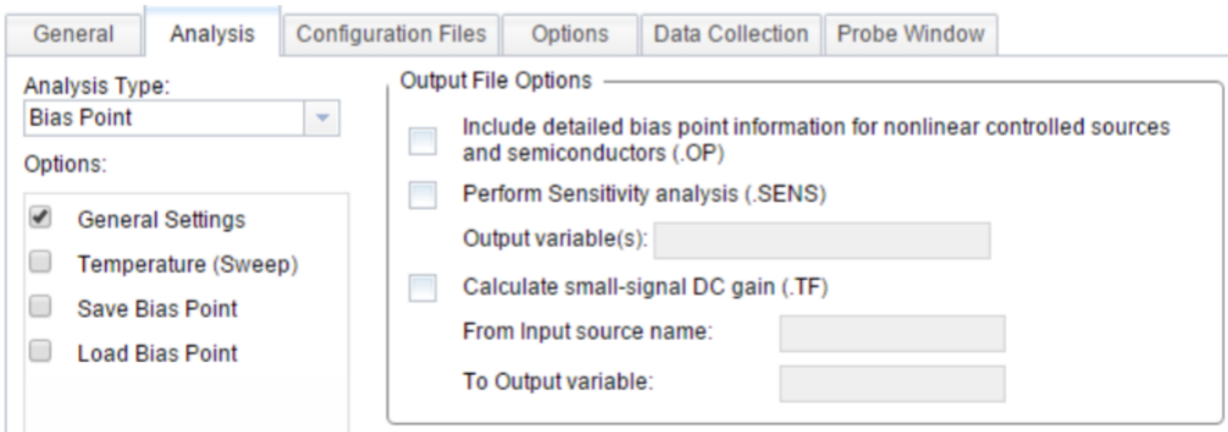
3. Now if Vo = 4V, R2 = 500 ohm, what is Vcc?

   Ic = 10mA, 10mA = (Vcc-4V)/500ohm, Vcc = 5-4 = 1V

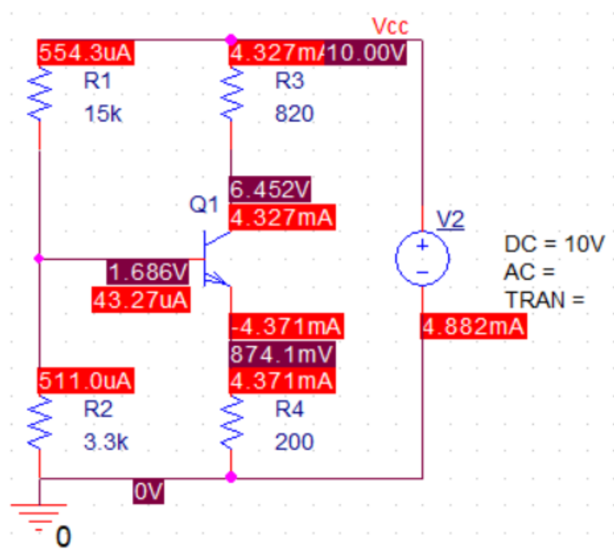
Figure 3 (SIM)

Schematic same as in lab portion of this report.

Simulation Profile



PSpice Generated Bias Point Simulation



Beta = Ic/Ib = 4.327mA/43.27uA = 100

Analysis

Addendum or Reference

Excel Generated Data (some datasets may be linked if too large)

Figure 1 (LAB)

	Vcc (V)	Vce [V]	Ic [mA]
Ib = 20uA	0	0.01007	0.02073
Vbe = 1.8V	1	0.459	1.15
R = 51K, 470	2	1.443	1.179
Vs=1.69V	3	2.43	1.192
	4	3.43	1.21E+00
	5	4.415	1.22E+00
	6	5.405	1.23E+00
	7	6.39	1.24E+00
	8	7.408	1.26E+00
	9	8.393	1.27E+00
	10	9.399	1.29E+00

Figure 2 (LAB)

	Vcc (V)	Vce [V]	Ic [mA]
Ib = 40uA	0	1.64E-02	3.40E-02
Vbe = 2.8V	1	0.326	1.39E+00
R = 51K, 470	2	0.811	2.51E+00
Vs=2.73V	3	1.792	2.55E+00
	4	2.78	2.59E+00
	5	3.75	2.62E+00
	6	4.74	2.65E+00
	7	5.712	2.68E+00
	8	6.712	2.71E+00
	9	7.7	2.75E+00
	10	8.68	2.78E+00

	Vcc (V)	Vce [V]	Ic [mA]
Ib = 60uA	0	2.03E-02	0.0395

Vbe = 3.8V	1	0.417	1.276
R = 51K, 470	2	0.6	2.99
Vs=3.76V	3	1.172	3.895
	4	2.14	3.966
	5	3.103	4.028
	6	4.08	4.088
	7	5.035	4.143
	8	6	4.21
	9	7	4.263
	10	7.985	4.326

Figure 3 (LAB)

	Vc	Ve	Vce [V]	Ib [mA]	Ic [mA]	gain (beta)
R1=14.7k	7	1.2	5.8	0.06481	4.684	72.2728
R3=680						

Figure 1 (SIM)

[2200L-L5model1.xlsx]

Figure 2 (SIM)

[2200L-L5model2.xlsx]

[2200L-L5model2.1.xlsx]

[2200L-5model2.2.xlsx]