Lab 2: Current Flow in the Bipolar Junction Transistor

ELEC 3908 A-A3

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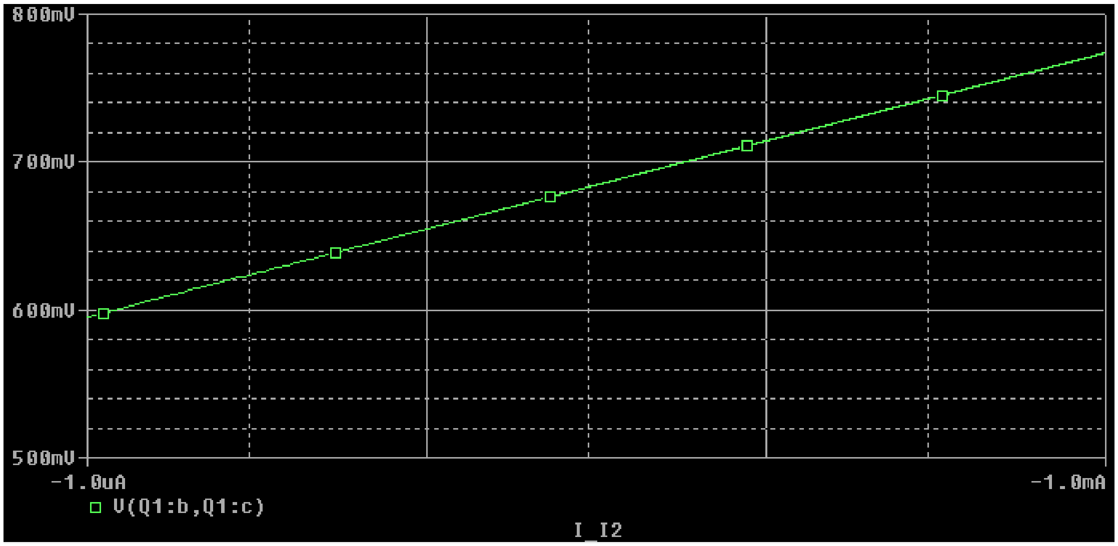
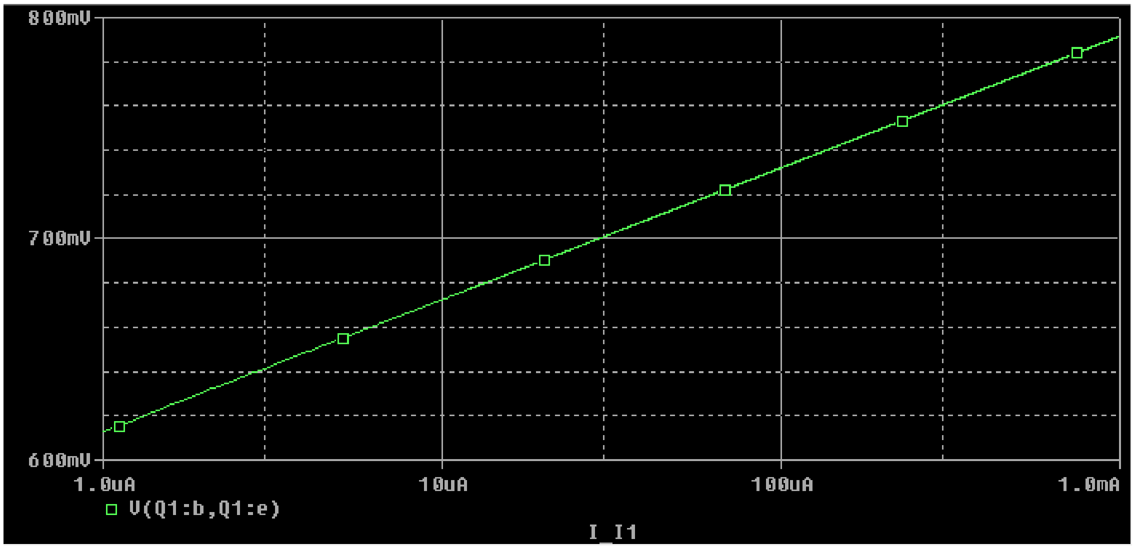
Date Performed: 20 - November - 2020

3.0 EXPERIMENT

3.1 Ebers-Moll Parameters of BC Junction

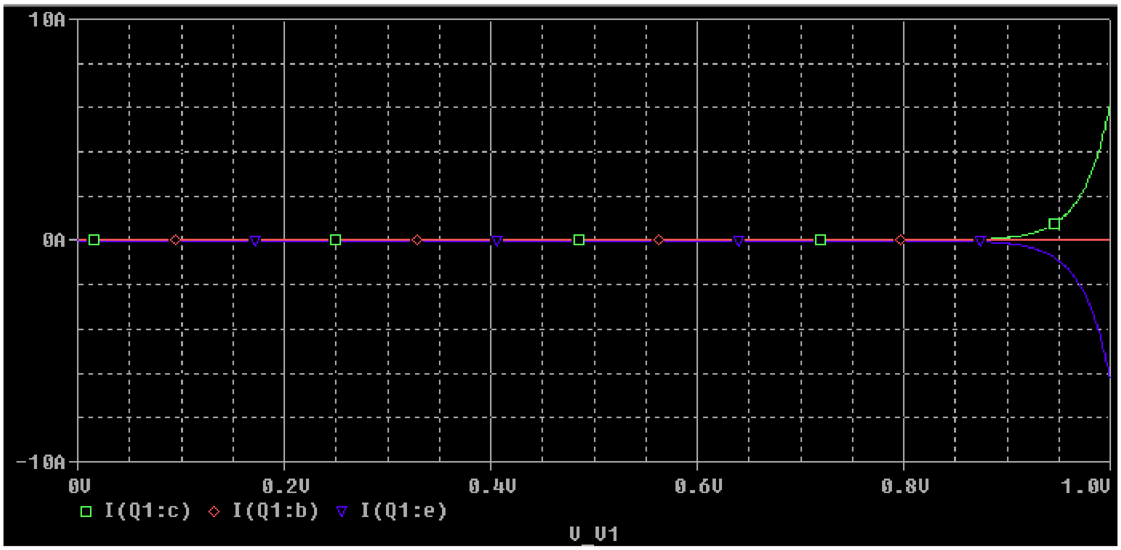


3.2 Ebers-Moll Parameters of BE Junction

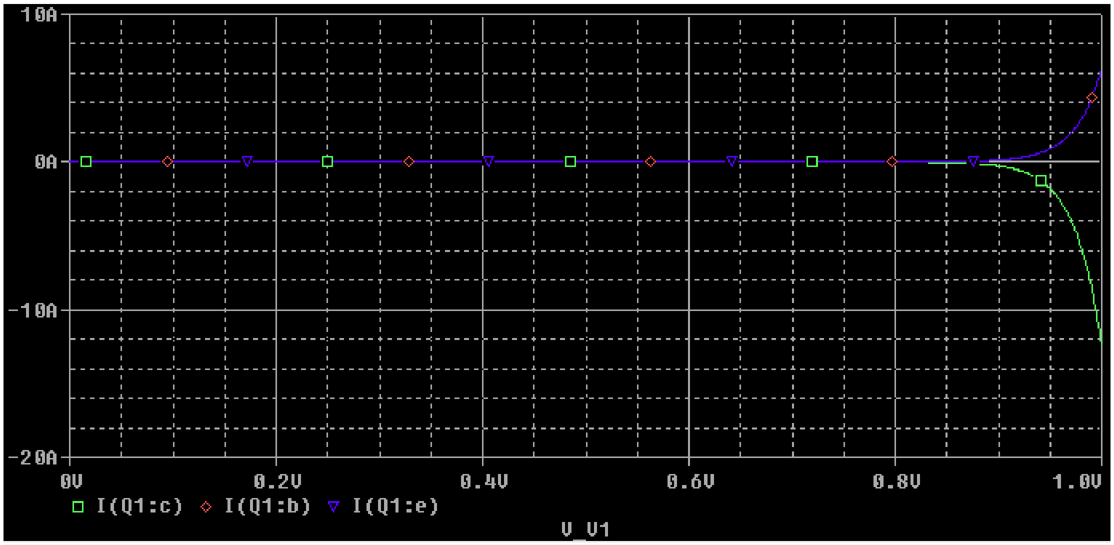


3.3 Forward and Reverse Current Gains

- 3.3 Forward Current Gain

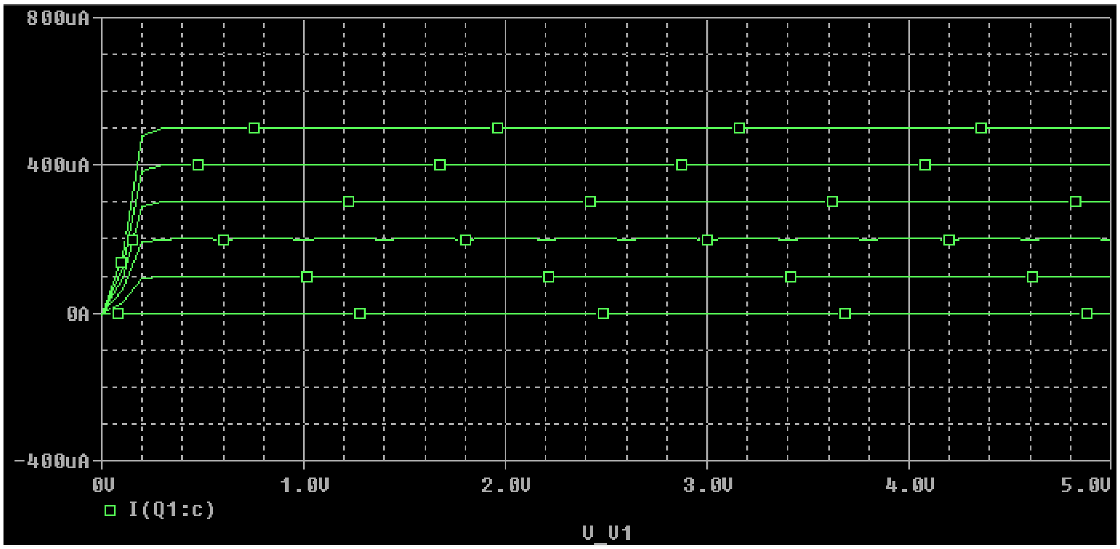


- 3.3 Reverse Current Gain

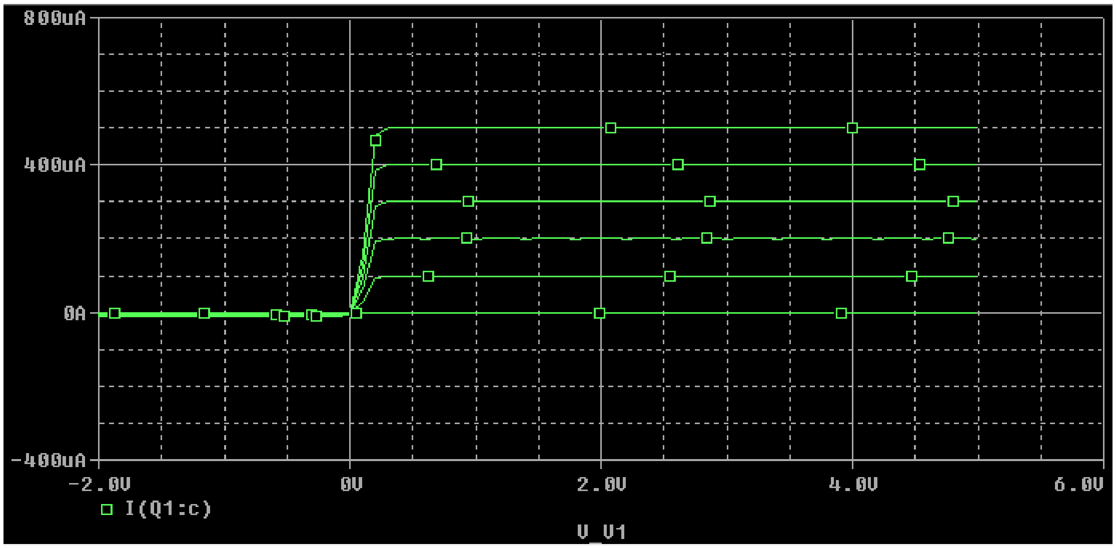


3.4 BJT I-V Characteristics

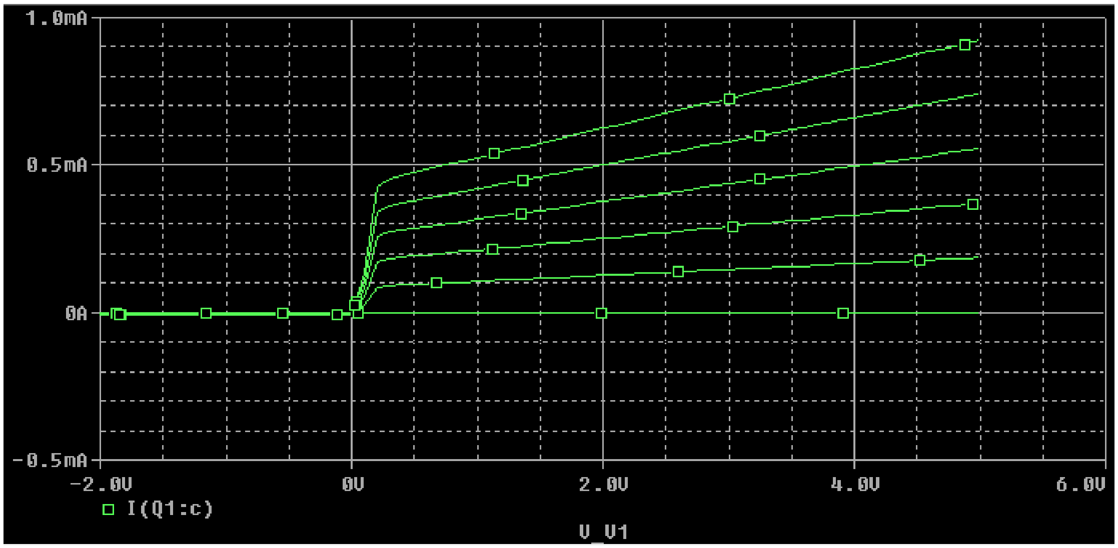
- NPN I-V Characteristics 0V to 5V



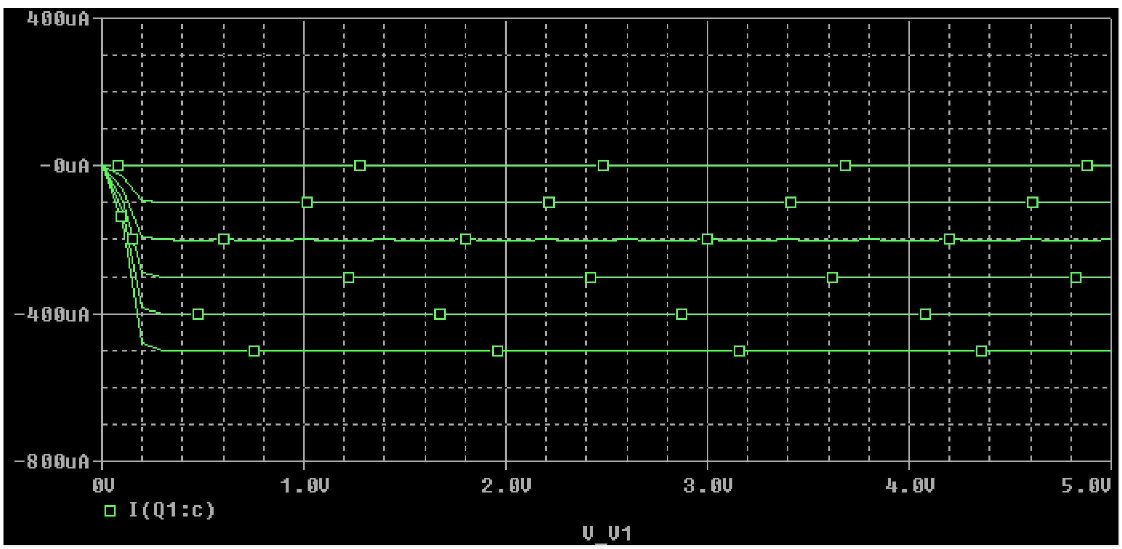
- NPN I-V Characteristics -2V to 5V



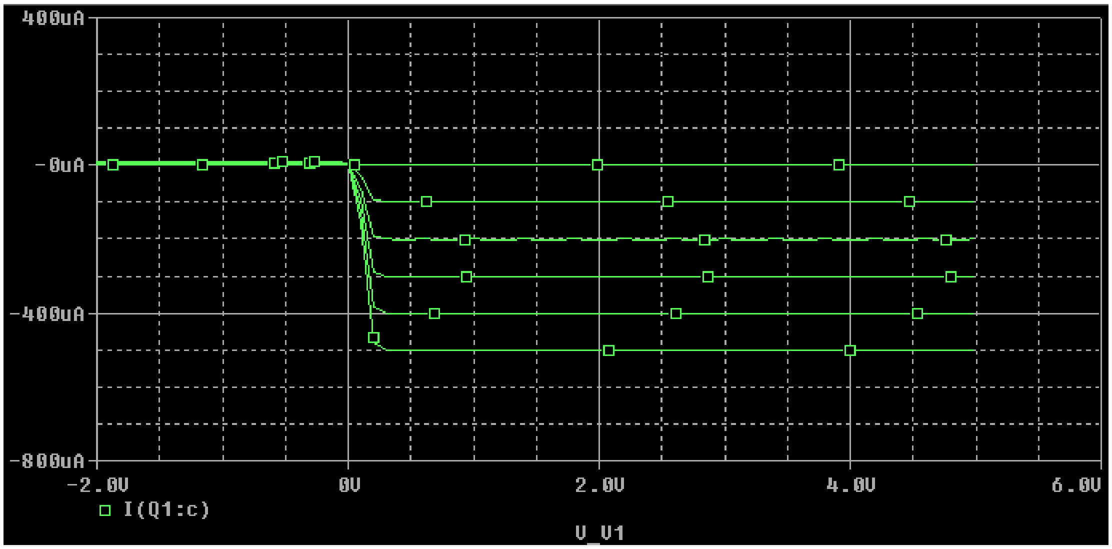
- NPN I-V Characteristics -2V to 5V VAF = 5



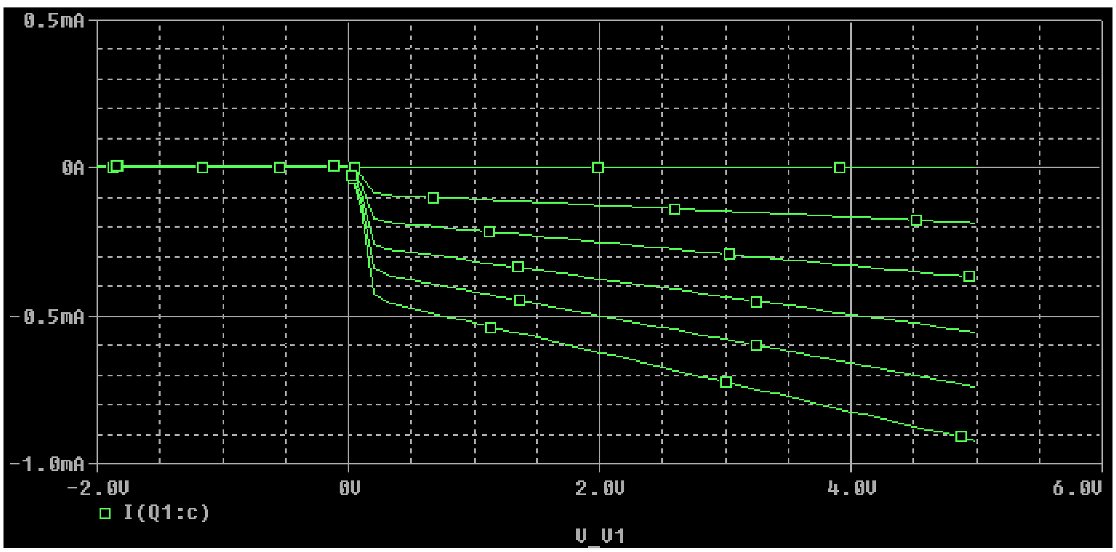
- PNP I-V Characteristics 0V to 5V



- PNP I-V Characteristics -2V to 5V

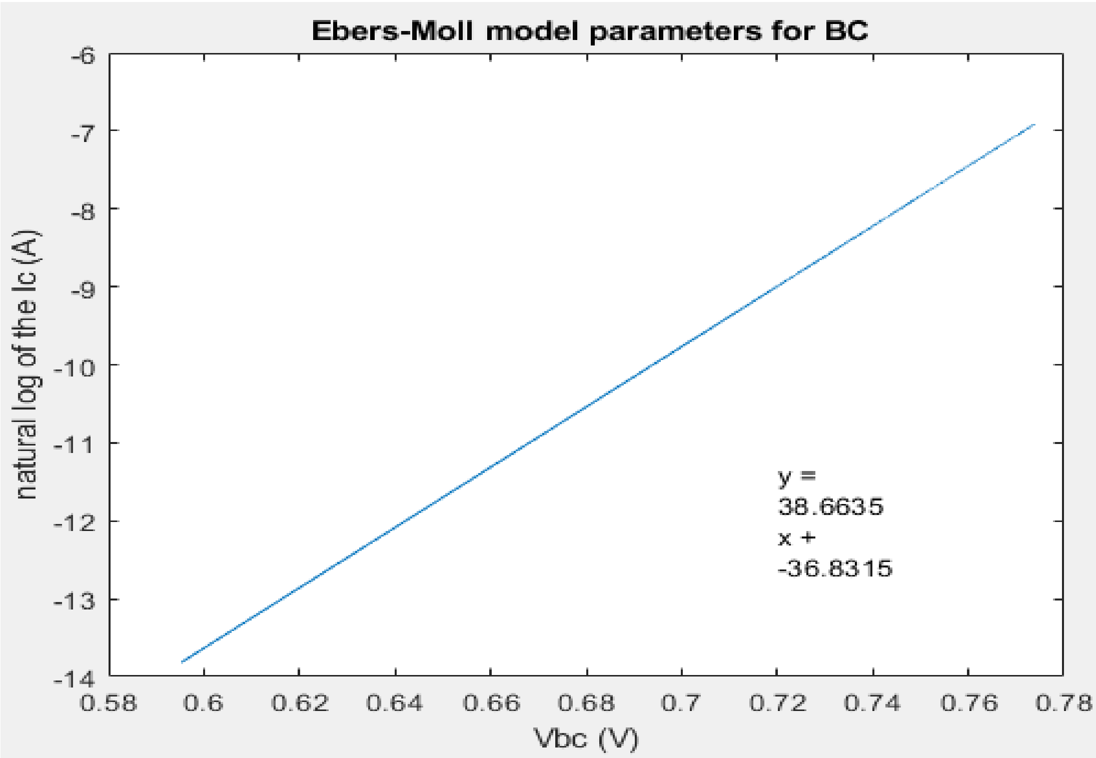


- PNP I-V Characteristics -2V to 5V VAF=5

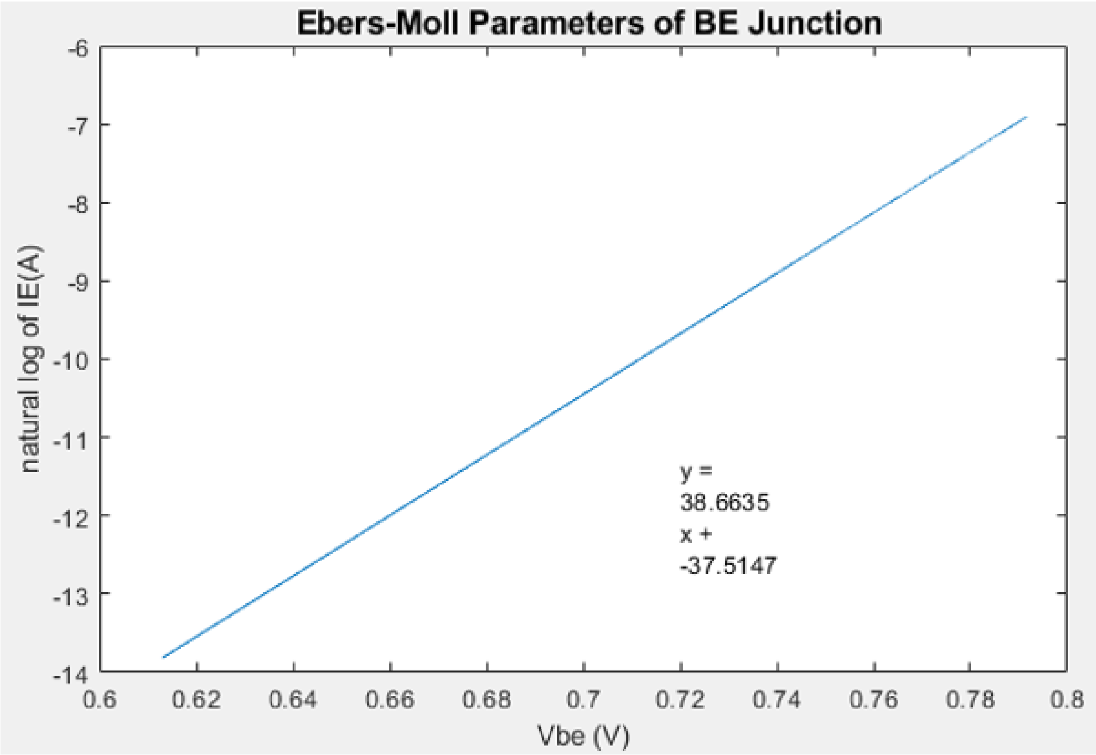


3.5 Plots in MatLab

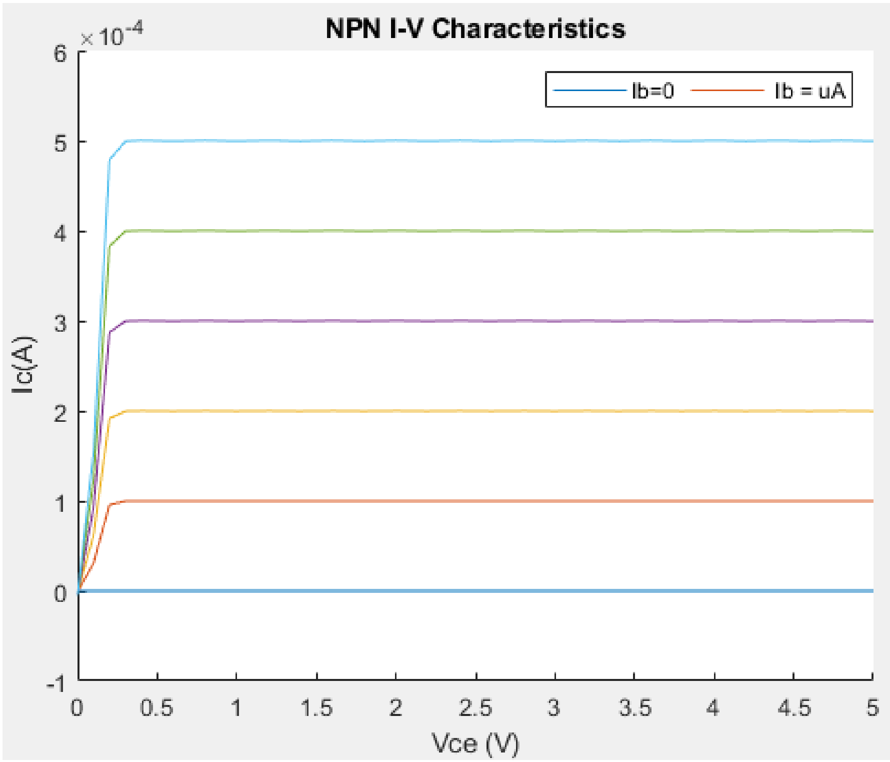
- Ebers-Moll Parameters of BC Junction



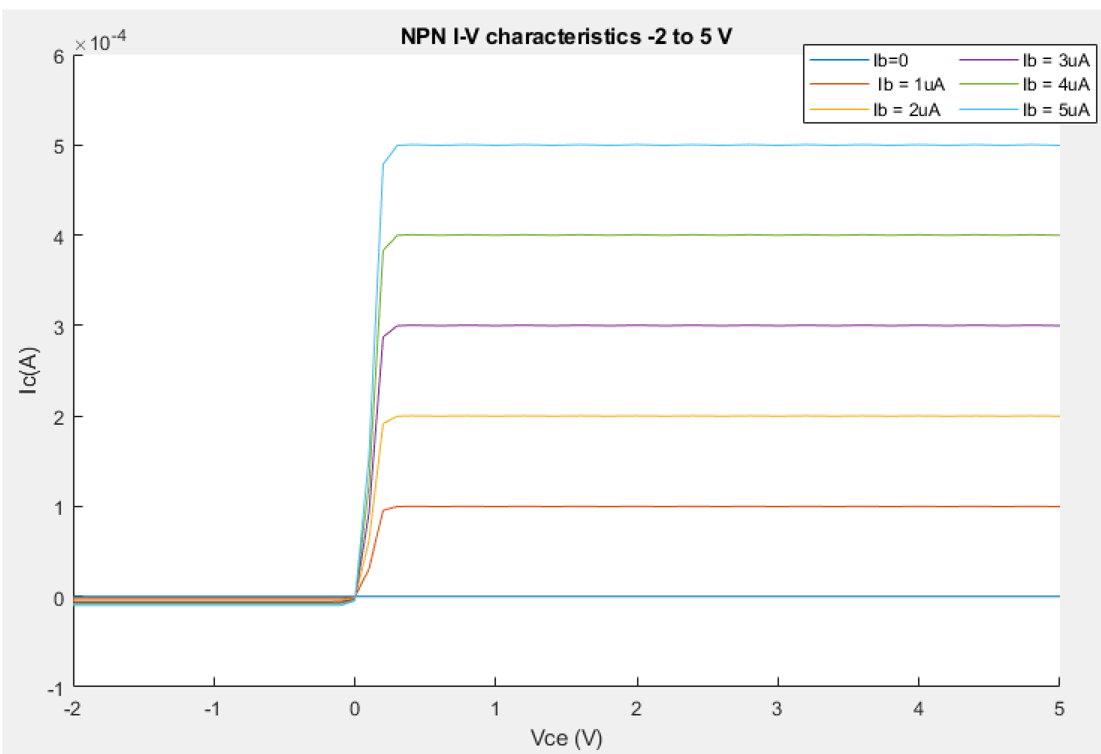
- Ebers-Moll Parameters of BE Junction



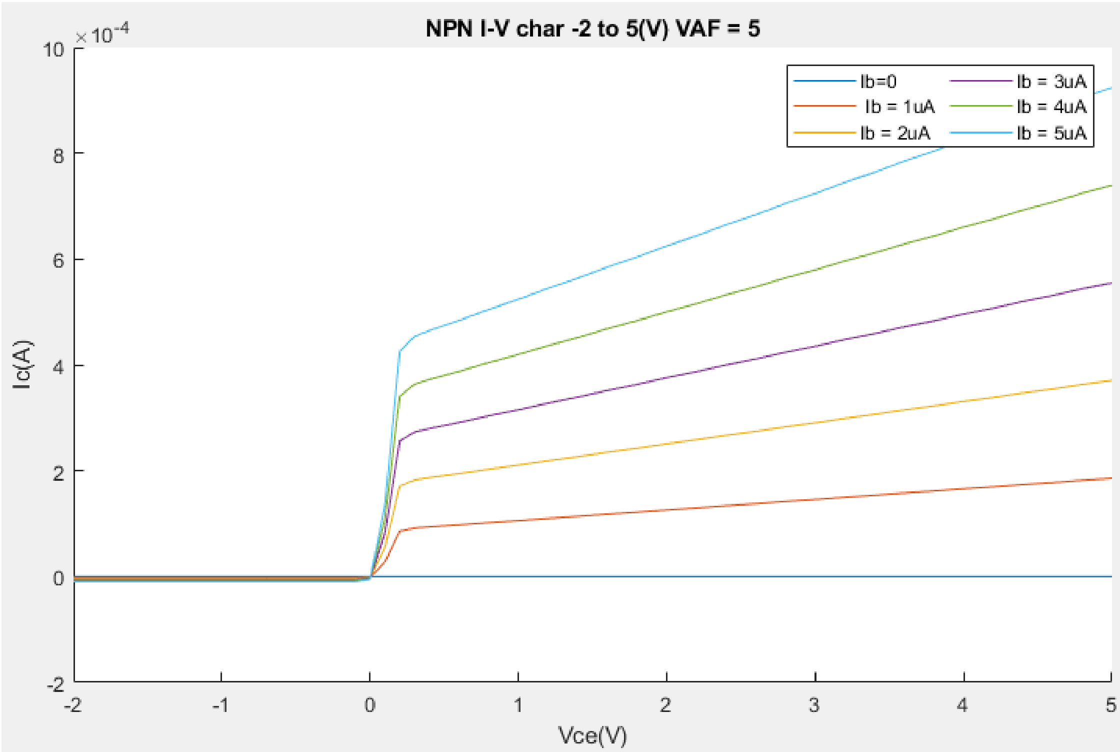
- NPN I-V Characteristics



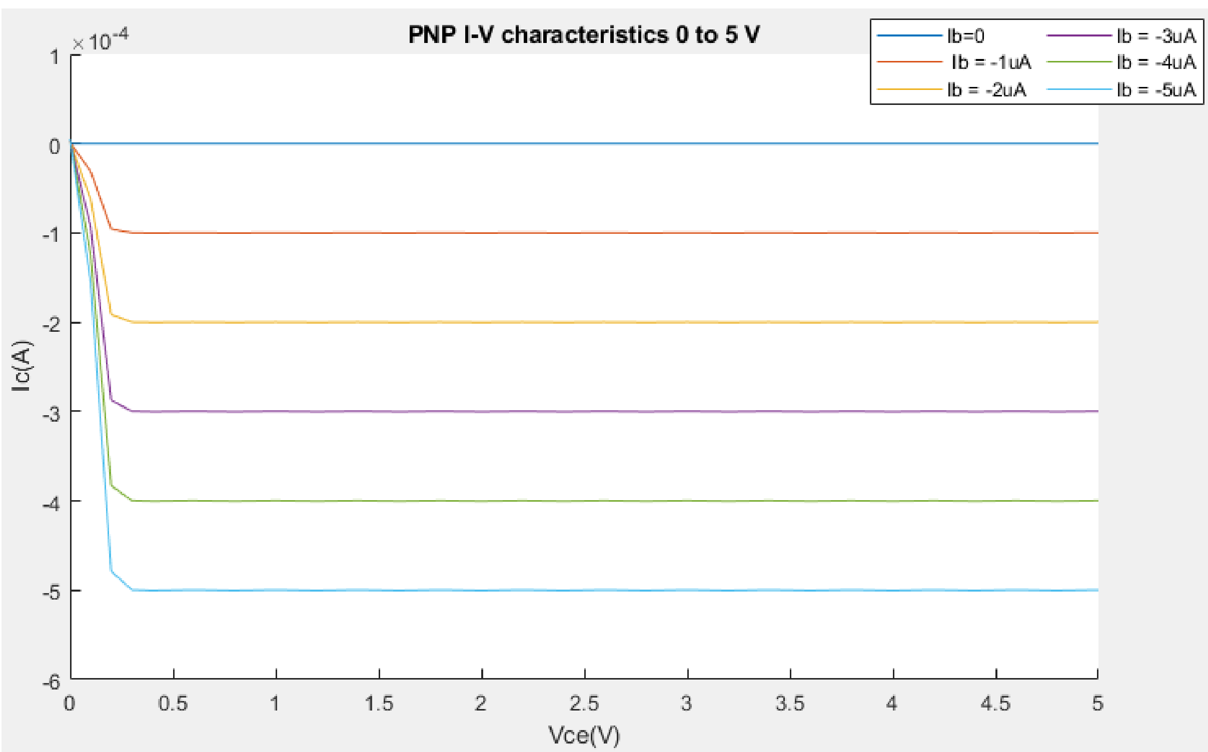
- NPN I-V Characteristics -2V to 5V



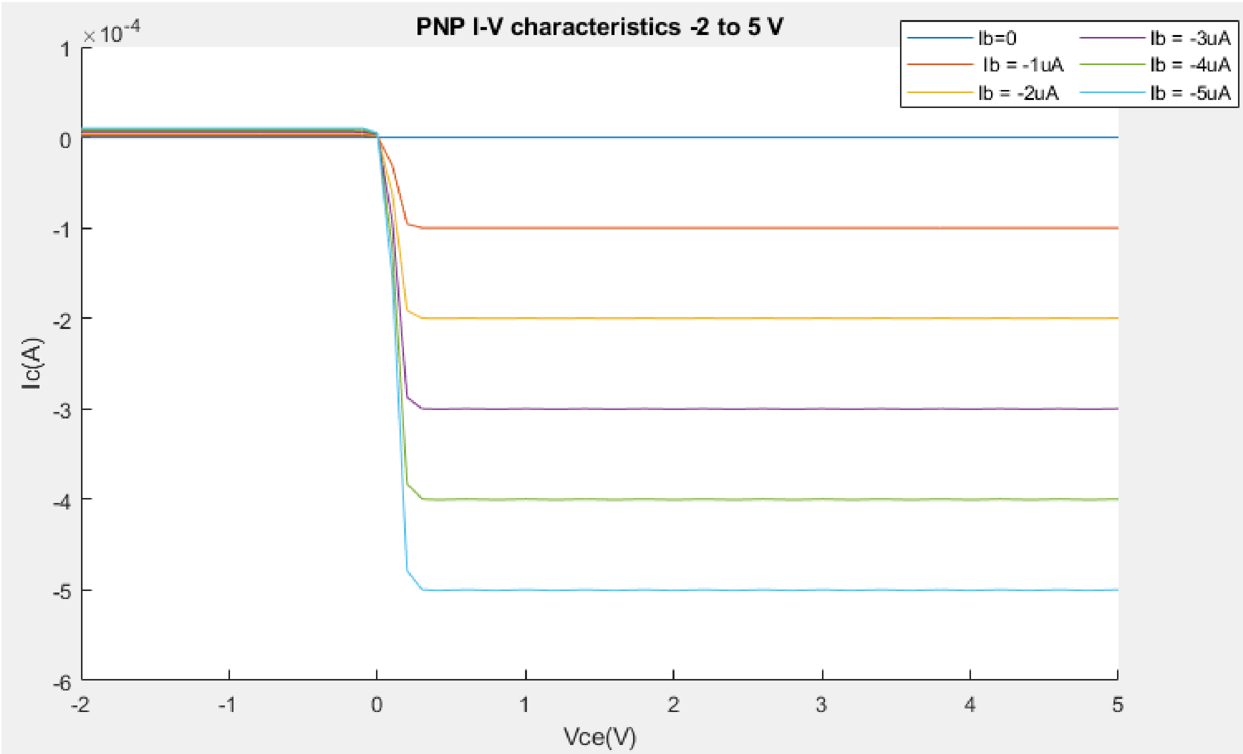
- NPN I-V Characteristics -2V to 5V VAF = 5



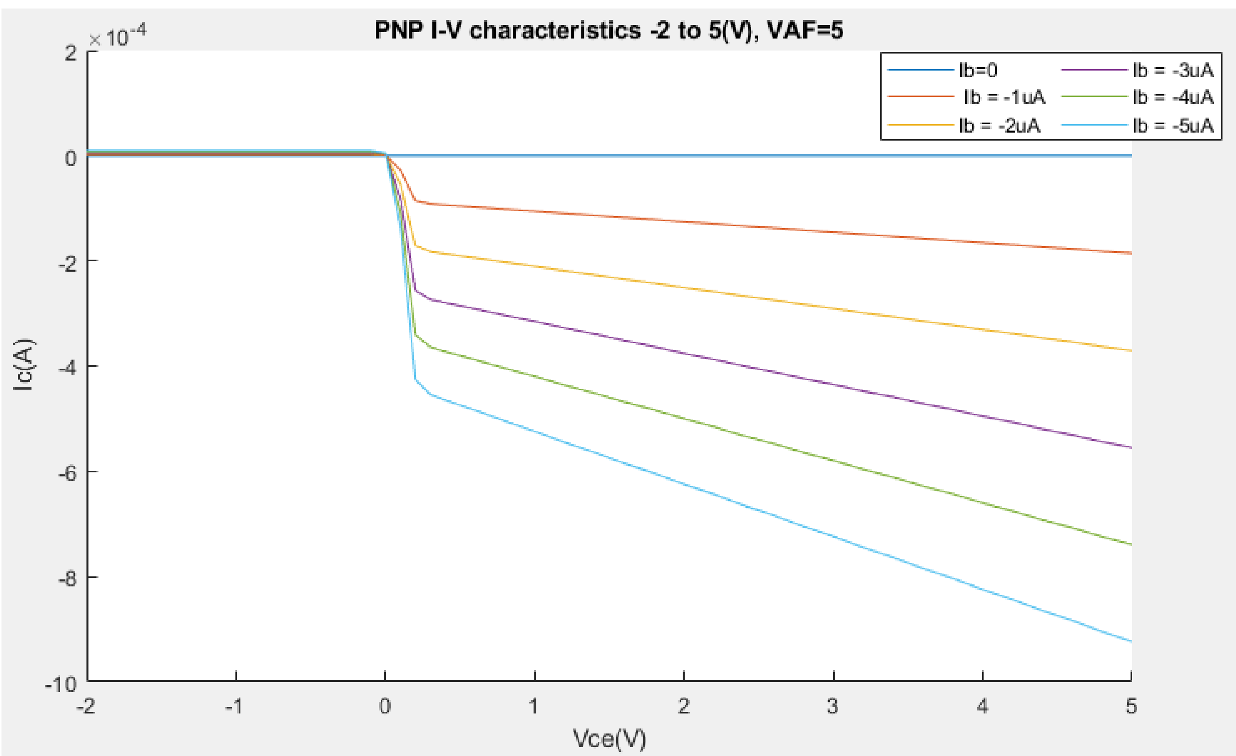
- PNP I-V Characteristics 0V to 5V



- PNP I-V Characteristics -2V to 5V



- PNP I-V Characteristics -2V to 5V VAF = 5



4.0 DATA ANALYSIS

4.1 Parameter Extraction

- $ln(I_C)$ vs V_{BC}:

$\frac{n_c kT}{q} = \frac{1}{Slope} = \frac{1}{38.6635} = 0.02586$

$n_c = \frac{0.02586}{0.0259} = 0.9986$

$ln(I_{Cs}) = -36.8315$

$I_{Cs} = 1 \times 10^{-16}$ A

- $ln(I_E)$ vs V_{BE}:

$\frac{n_E kT}{q} = \frac{1}{Slope} = \frac{1}{38.6635} = 0.02586$

$n_E = \frac{0.02586}{0.0259} = 0.9986$

$ln(I_{Es}) = -37.5147$

$I_{Es} = 5.1 \times 10^{-17}$ A

	Forward	**Reverse**
Alpha(α)	0.9901	0.5
Beta(β)	100	1

- $\beta_F = \frac{\alpha_F}{1-\alpha_F}$; $\beta_R = \frac{\alpha_R}{1-\alpha_R}$; $\alpha_F = 0.9901$; $\beta_F = 100$; $\alpha_R = 0.5$; $\beta_R = 1$

$\alpha_F = \frac{\beta_F}{1+\beta_F} = \frac{100}{1+100} = 0.9901$

$\alpha_R = \frac{\beta_R}{1+\beta_R} = \frac{1}{1+1} = 0.5$

$1 = \frac{\alpha_F}{\beta_F} + \alpha_F$; $1 = \frac{\alpha_R}{\beta_R} + \alpha_R$

$\frac{\alpha_F}{\beta_F} + \alpha_F = \frac{\alpha_R}{\beta_R} + \alpha_R$

$\frac{\alpha_F}{\beta_F} + \alpha_F = \frac{0.9901}{100} + 0.9901 = 1$

$\frac{\alpha_R}{\beta_R} + \alpha_R = \frac{0.5}{1} + 0.5 = 1$

Hence, α_F, β_F, α_R, and β_R are all related by the equation shown above.

V_{BE}	V_{BC}	Sim. I_C	Calc. I_C	% error	Sim. I_B	Calc. I_B	% error
0	0.602	-1.30×10^{-6}	-1.28×10^{-6}	1.54	6.50×10^{-7}	6.42×10^{-7}	1.23
0	0.606	-1.50×10^{-6}	-1.50×10^{-6}	0.00	7.60×10^{-7}	7.49×10^{-7}	1.45
0	0.609	-1.70×10^{-6}	-1.68×10^{-6}	1.18	8.45×10^{-7}	8.41×10^{-7}	0.47

$$I_C = \alpha_F I_{Es}\left(e^{\frac{qV_{BE}}{n_E kT}} - 1\right) - I_{Cs}\left(e^{\frac{qV_{BC}}{n_C kT}} - 1\right)$$

$$I_C = 0.9901 * 5.1 * 10^{-17}(e^{38.6635*0} - 1) - 10^{-16}(e^{38.6635*0.602} - 1)$$

$I_C = -1.28 \times 10^{-6}$ A

$$I_B = (1 - \alpha_F)I_{Es}\left(e^{\frac{qV_{BE}}{n_E kT}} - 1\right) + (1 - \alpha_R)I_{Cs}\left(e^{\frac{qV_{BC}}{n_C kT}} - 1\right)$$

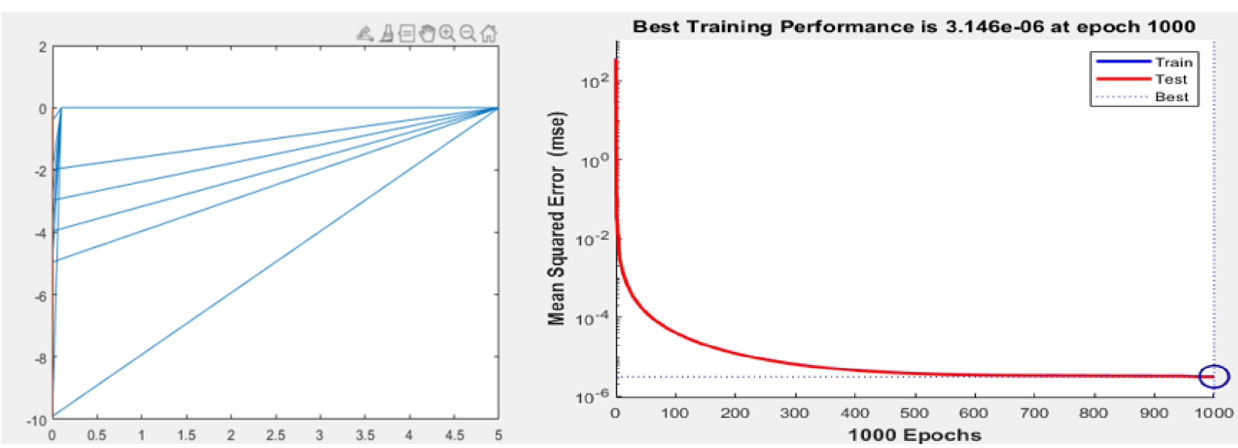
$$I_B = (1 - 0.9901)5.1 * 10^{-17}(e^{38.6635*0} - 1) + (1 - 0.5) * 10^{-16}(e^{38.6635*0.602} - 1)$$

$I_B = 6.42 \times 10^{-7}$ A

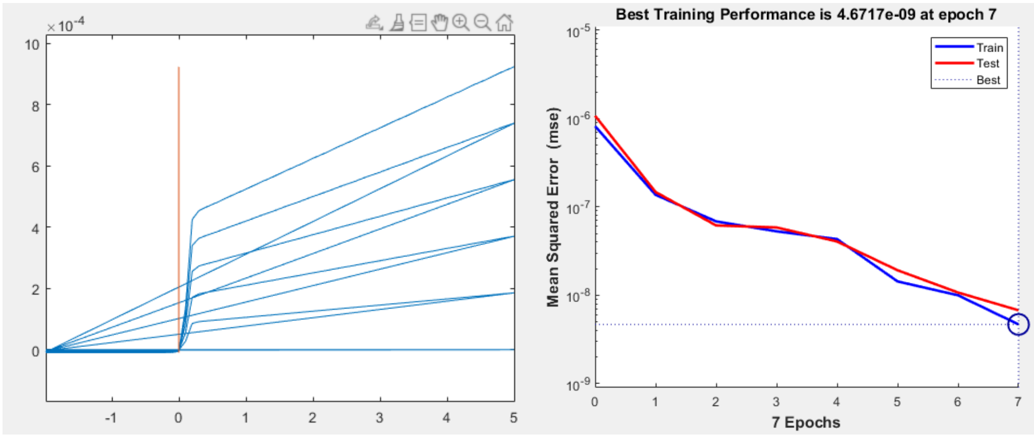
$$\text{\% error} = \left|\frac{calculated - simulated}{simulated}\right| * 100 = \left|\frac{(-1.28*10^{-6}) - (-1.30*10^{-6})}{(-1.30*10^{-6})}\right| * 100 = 1.54$$

4.2 Matlab Neural Net Development

- NPN I-V Characteristics NN Model



- NPN I-V Characteristics -2 to 5V VAF=5 NN Model



4.3 Discussion Question

- NPN is used more often than PNP since the NPN has e^- as its majority carriers but PNP has holes as its majority carriers. The mobility of e^- in NPN is better than hole in PNP, hence NPN is a better choice than the PNP.
- Simulations are usually theory and do not take into consideration, bad calculations or using the formula wrong, or maybe wrong data was mistakenly entered