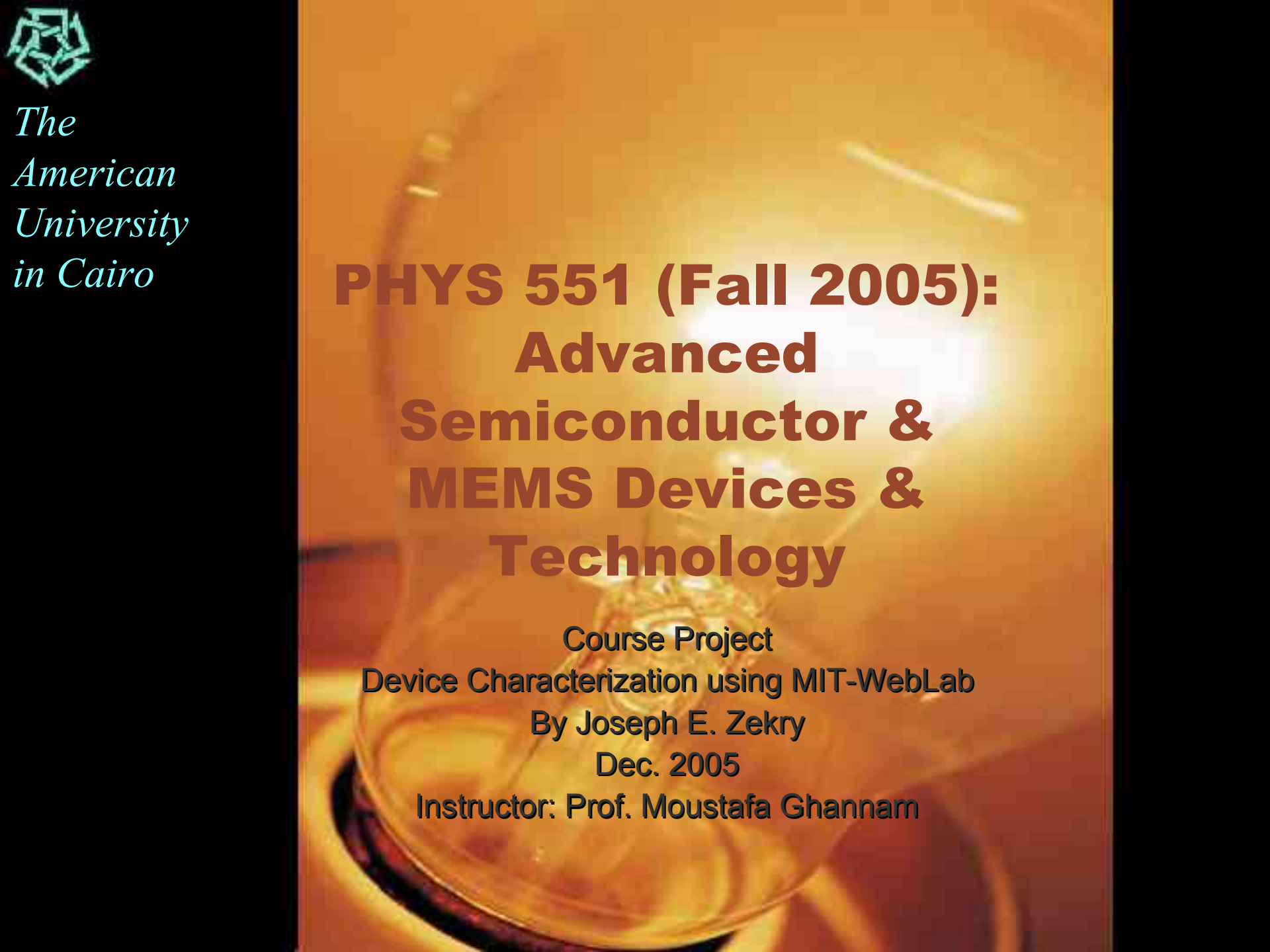


The American University in Cairo

PHYS 551 (Fall 2005): Advanced Semiconductor & MEMS Devices & Technology

Course Project

Device Characterization using MIT-WebLab

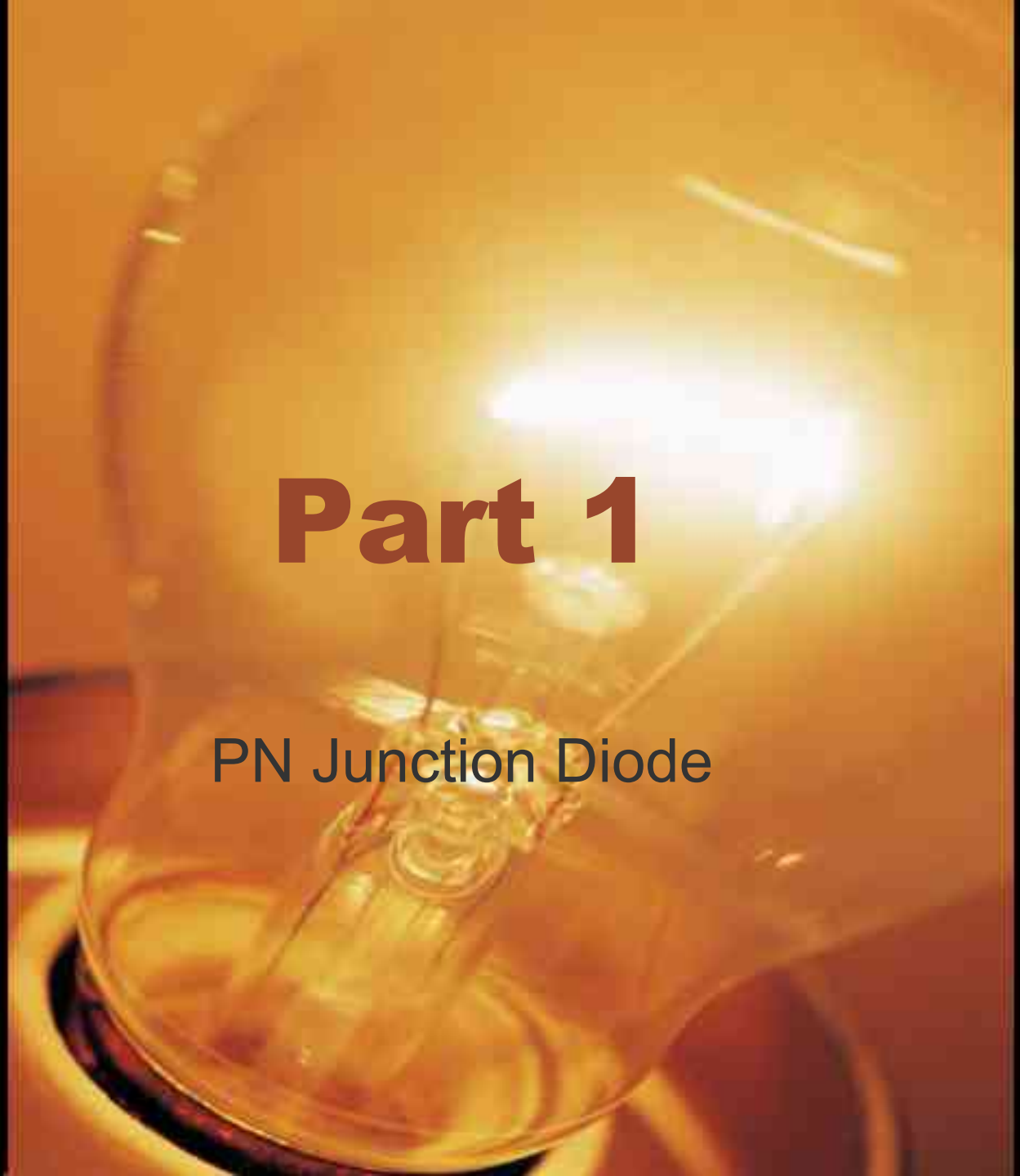
By Joseph E. Zekry

Dec. 2005

Instructor: Prof. Moustafa Ghannam

Project Outline

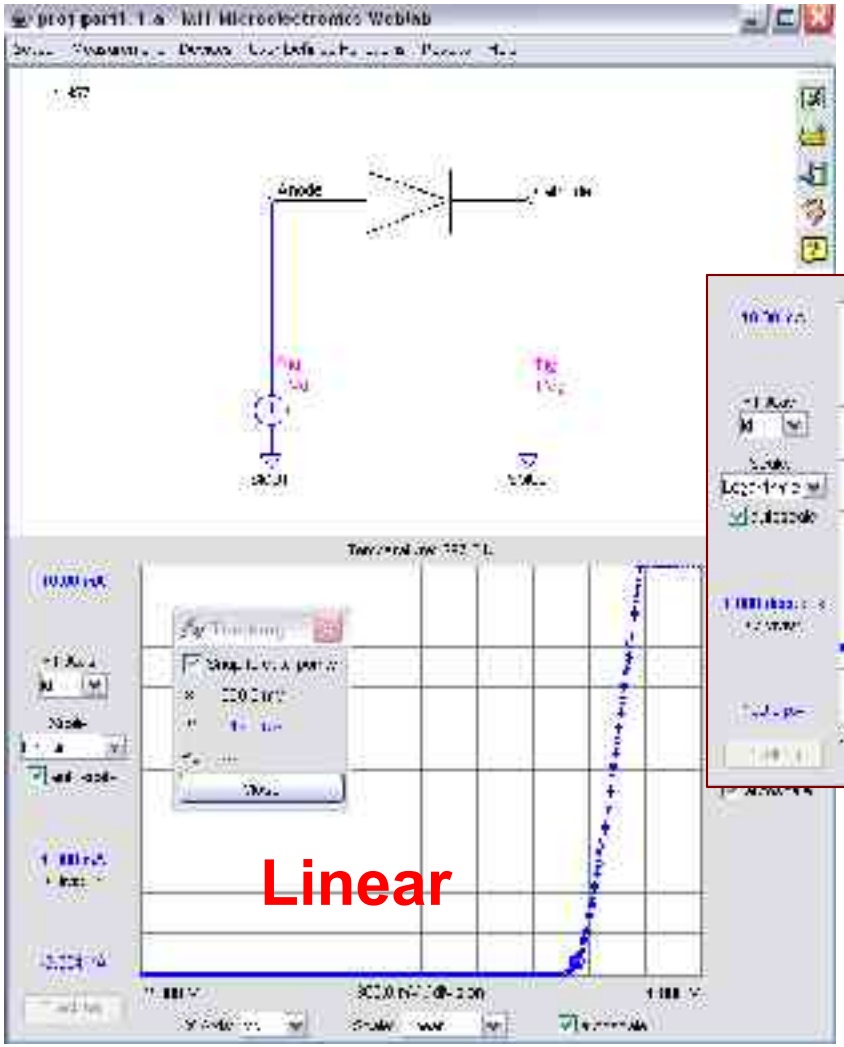
- **Part 1: pn junction diode**
  1. Plotting I-V c/c's using Weblab
  2. Plotting the Weblab data using MATLAB
  3. Fitting the c/c's to diode equation & extracting the diode parameters
- **Part 2: npn BJT**
  1. Plotting I_C -V_{CE} c/c's using Weblab & MATLAB
  2. Plotting transfer c/c's
  3. Determining the transistor parameters & temperature
  4. Determining reverse operation parameters
- **Part 3: nMOSFET**
  1. Plotting output c/c's
  2. Plotting transfer c/c's
  3. Determining the transistor parameters

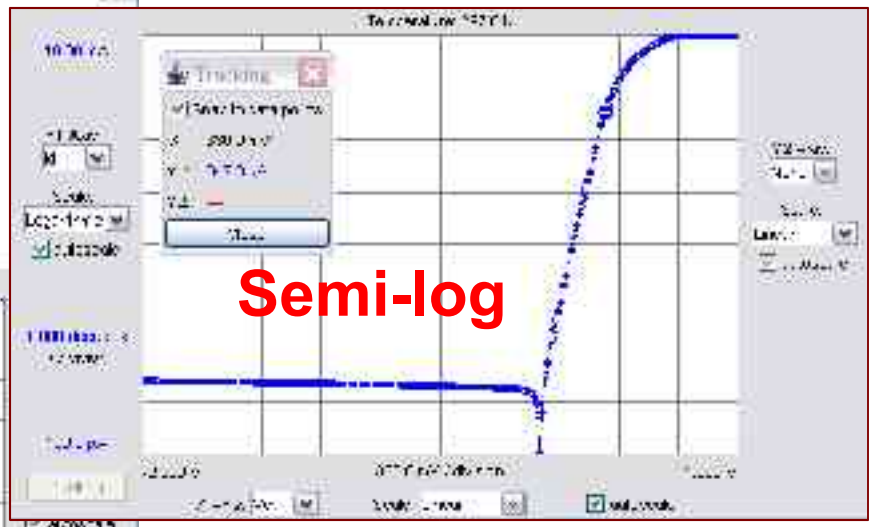


Part 1

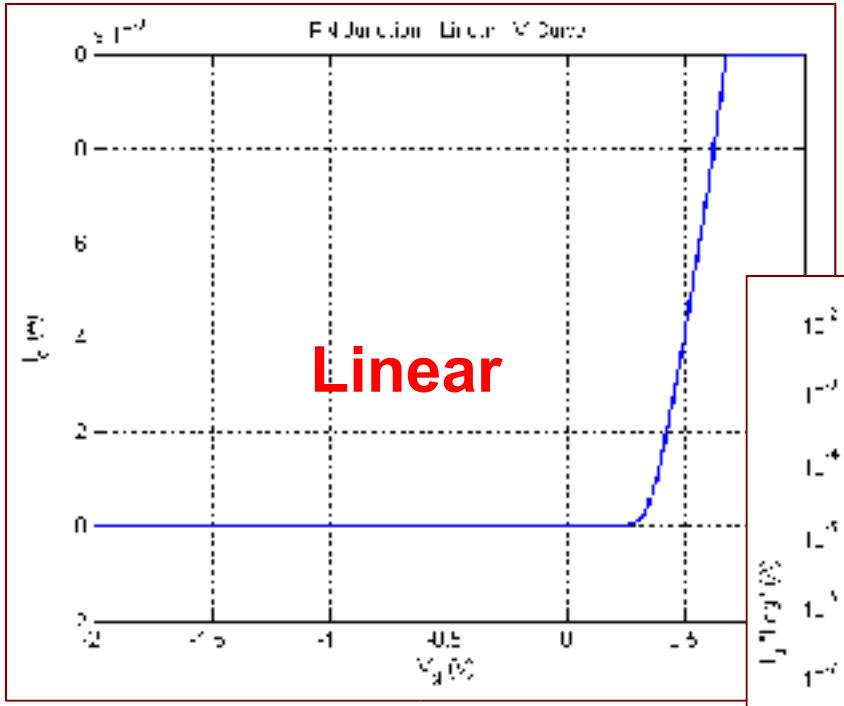
PN Junction Diode

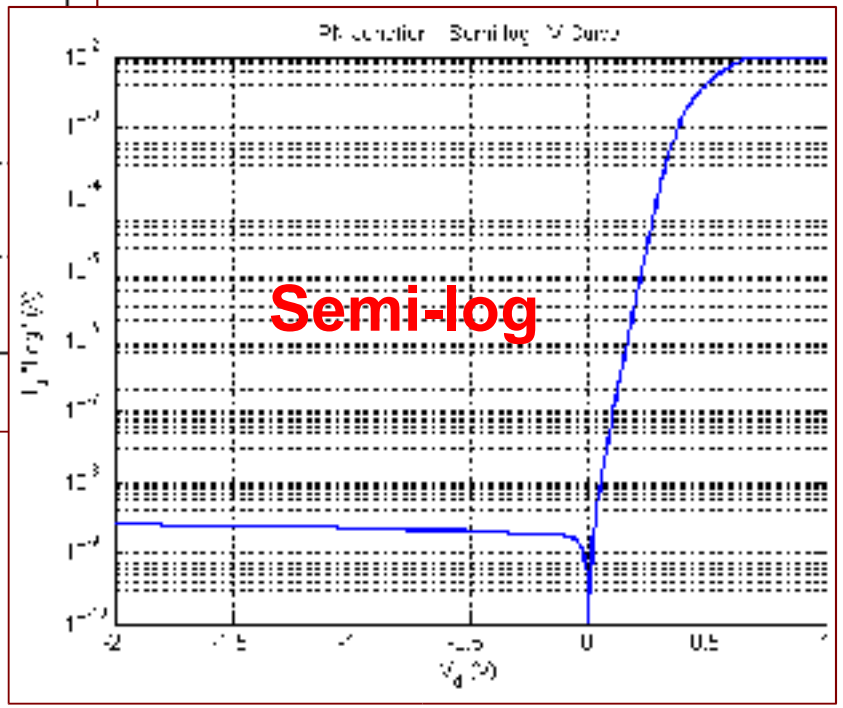
Diode characteristics (WebLab)





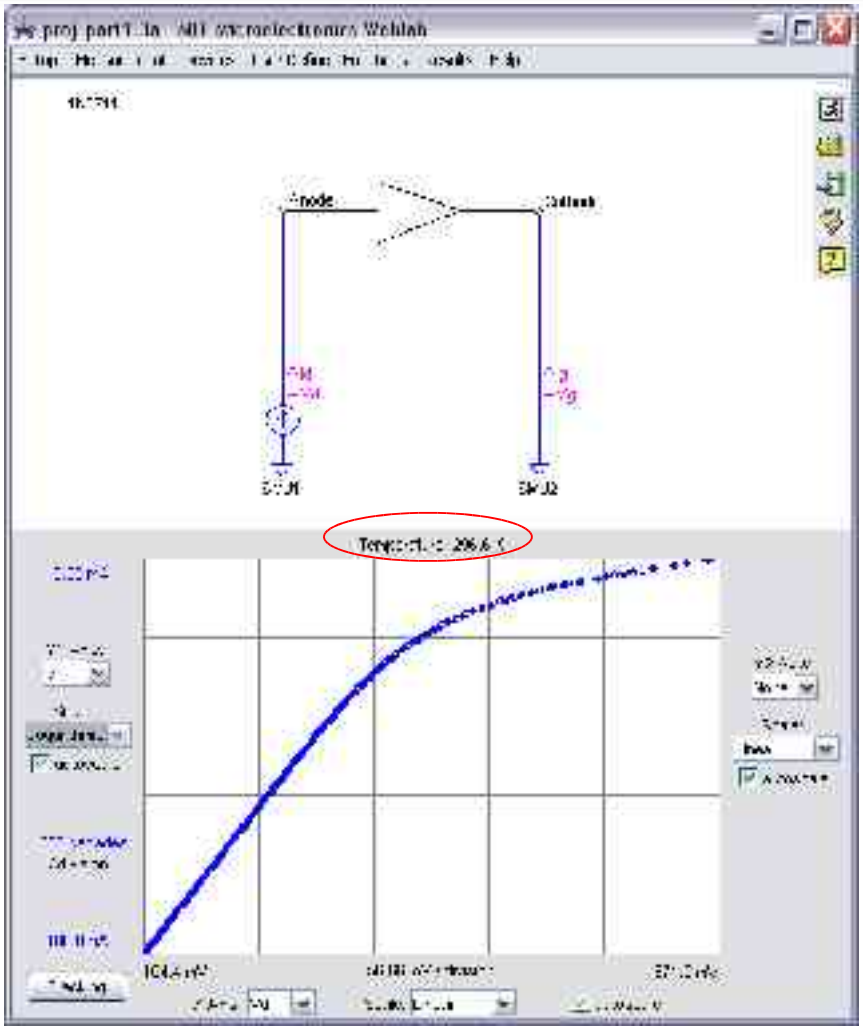
Diode characteristics (MATLAB)



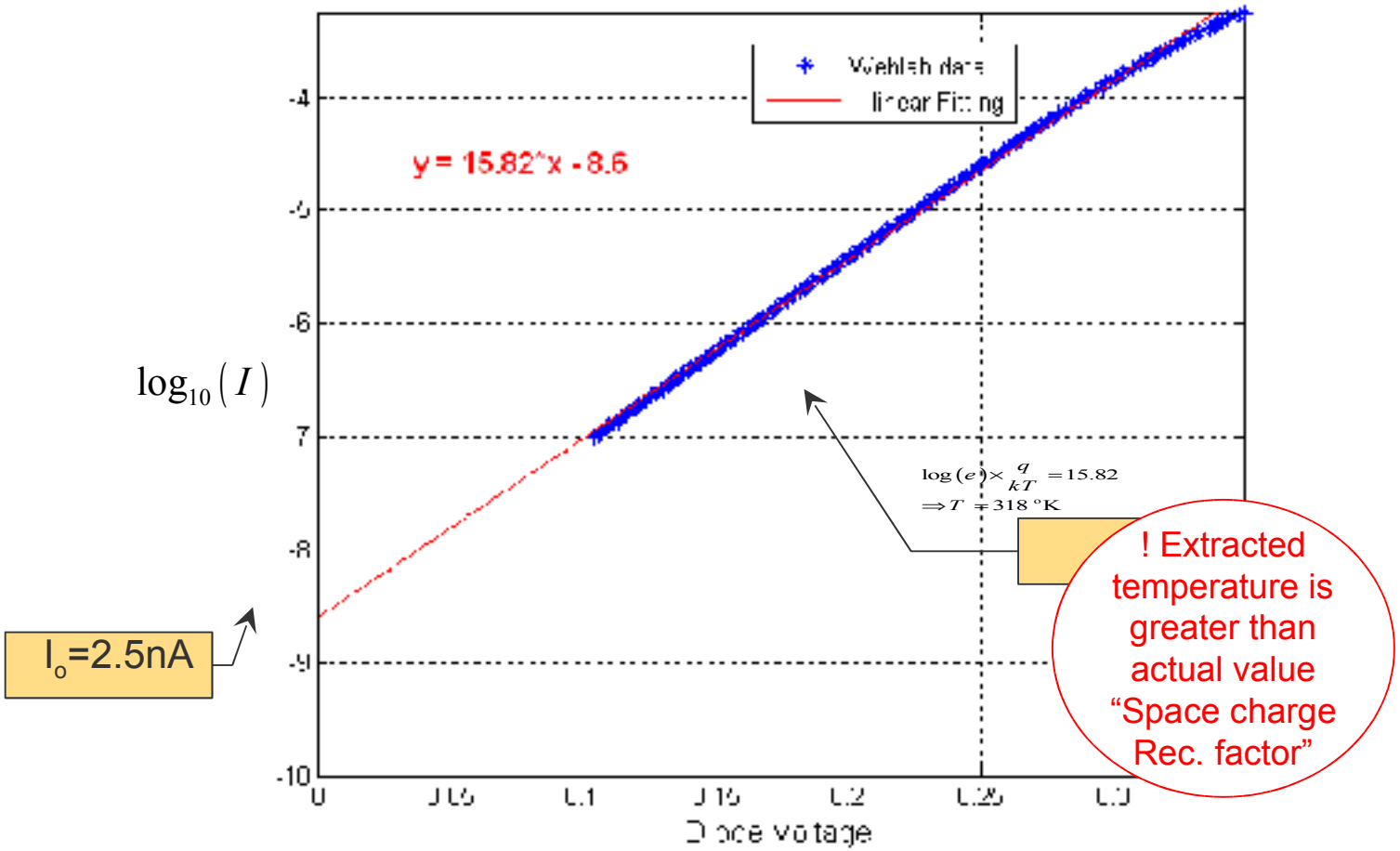


Extracting Diode Parameters

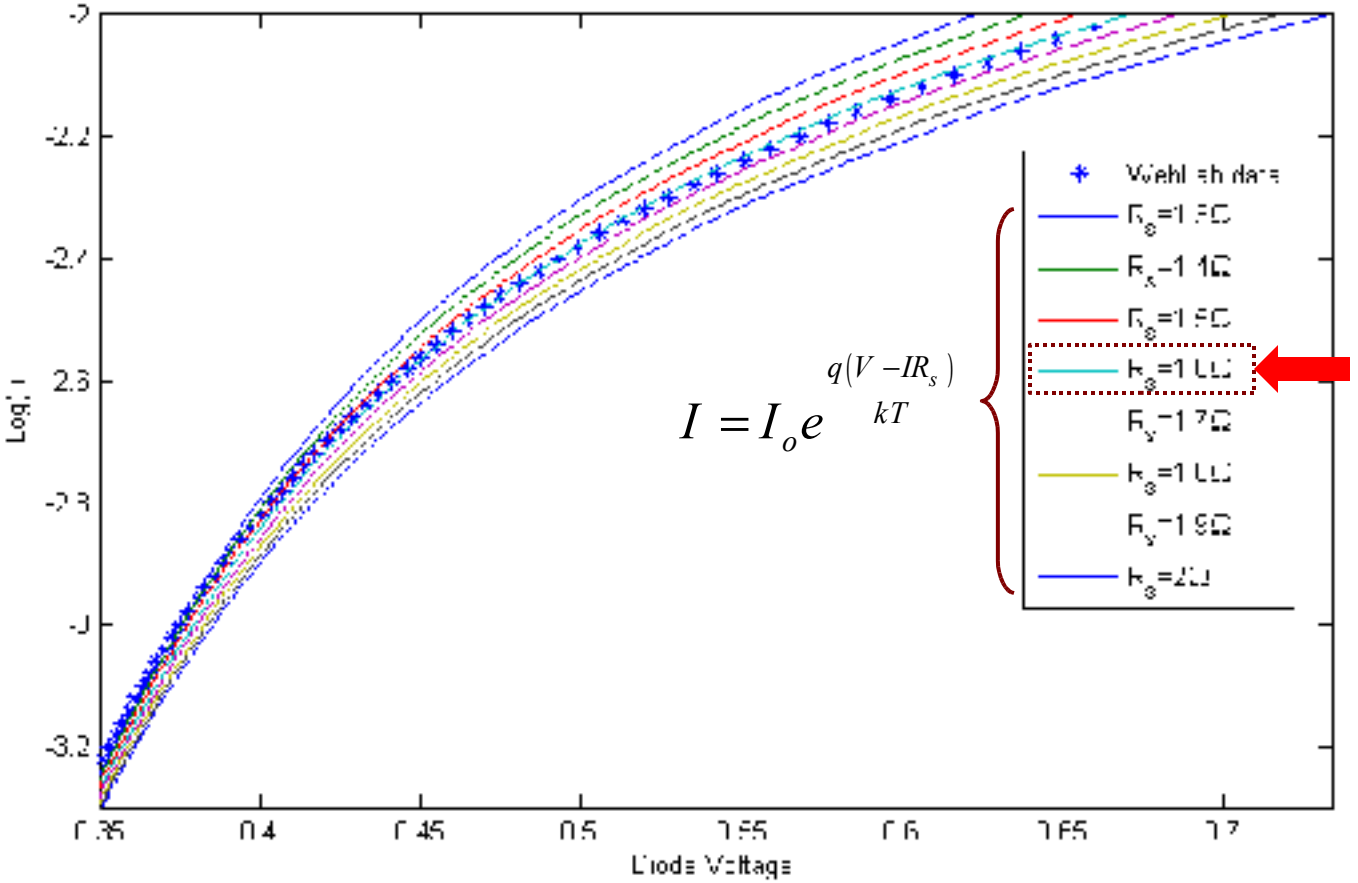
- Data obtained by Weblab for the forward operation (Log50 sweep for the diode current between 100nA and 10mA)

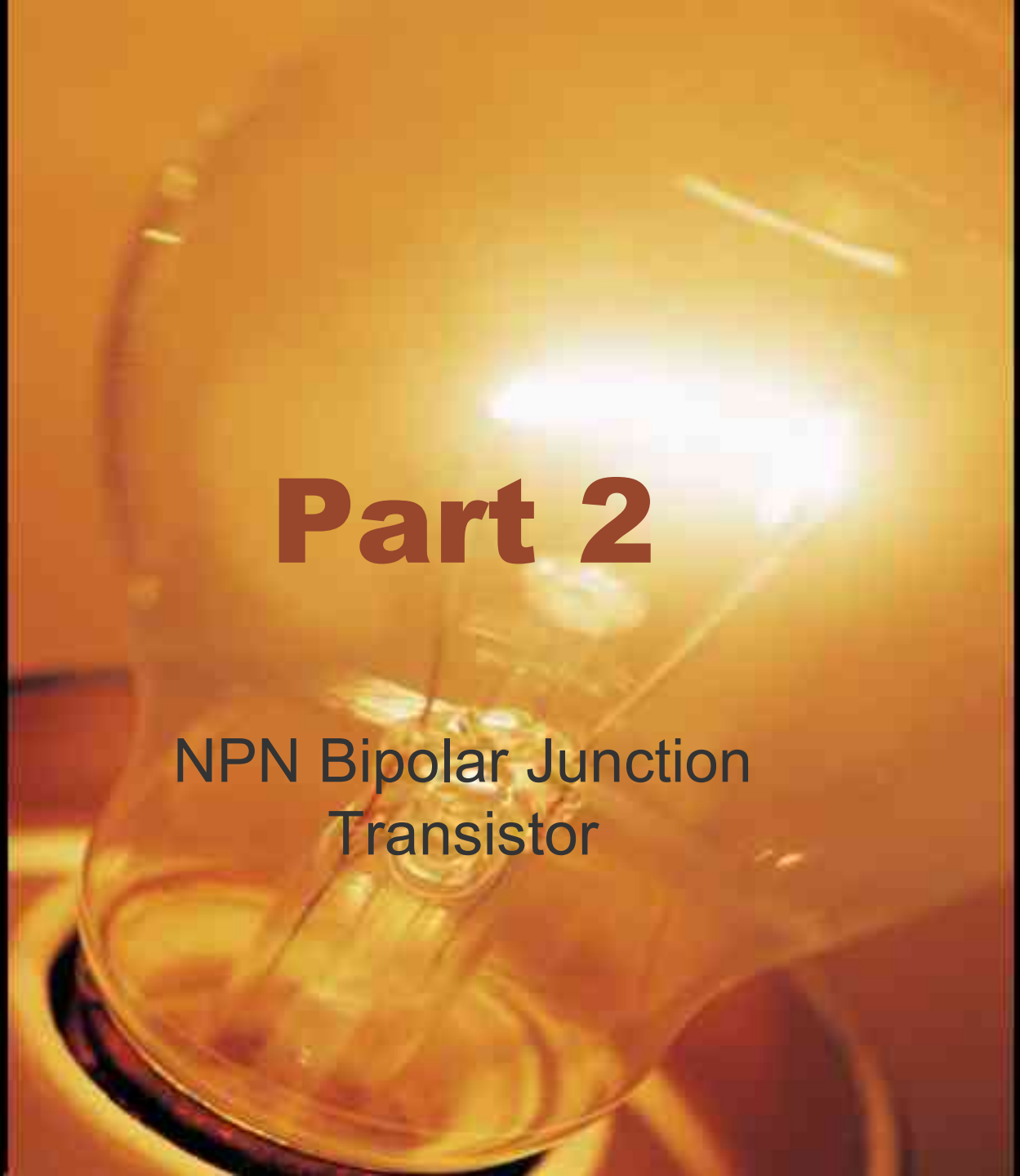


Extracting Diode Parameters



Diode Series Resistance

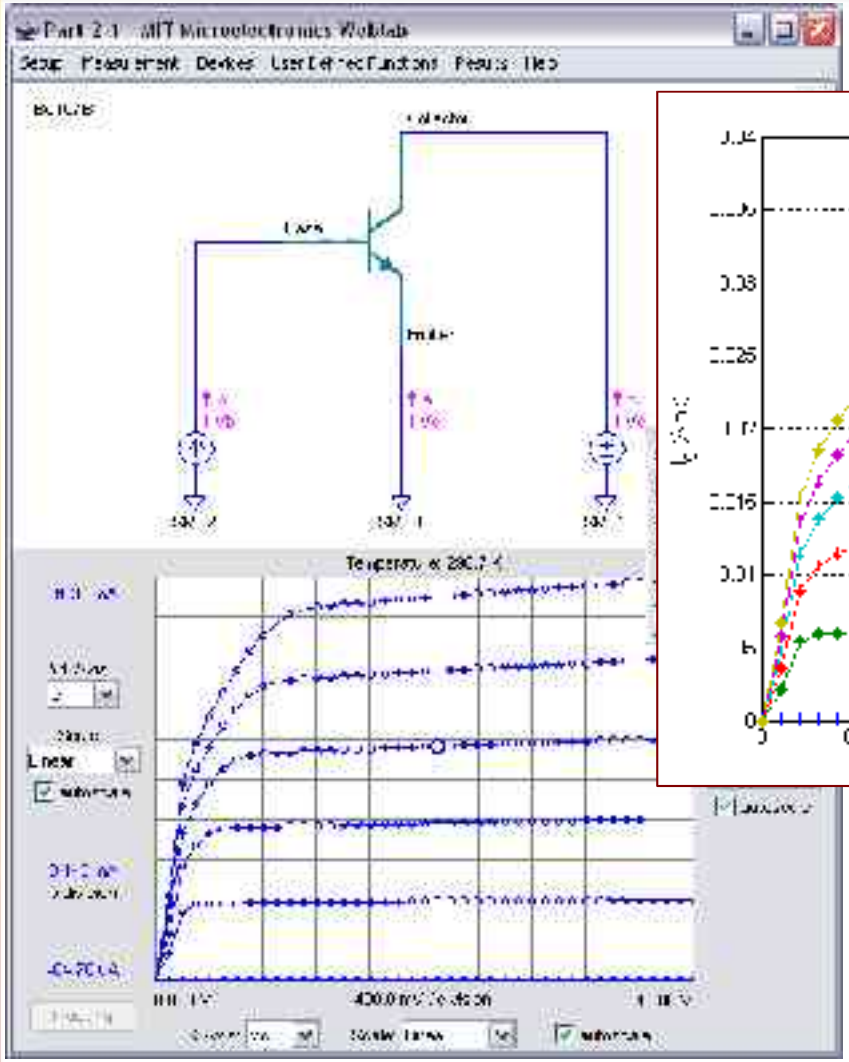


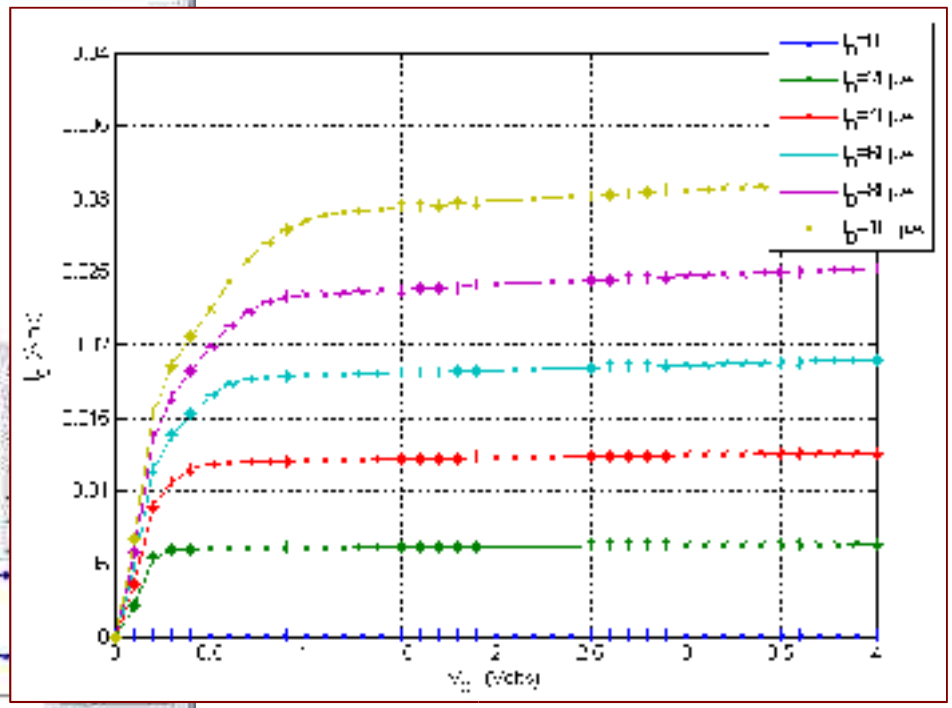


Part 2

NPN Bipolar Junction Transistor

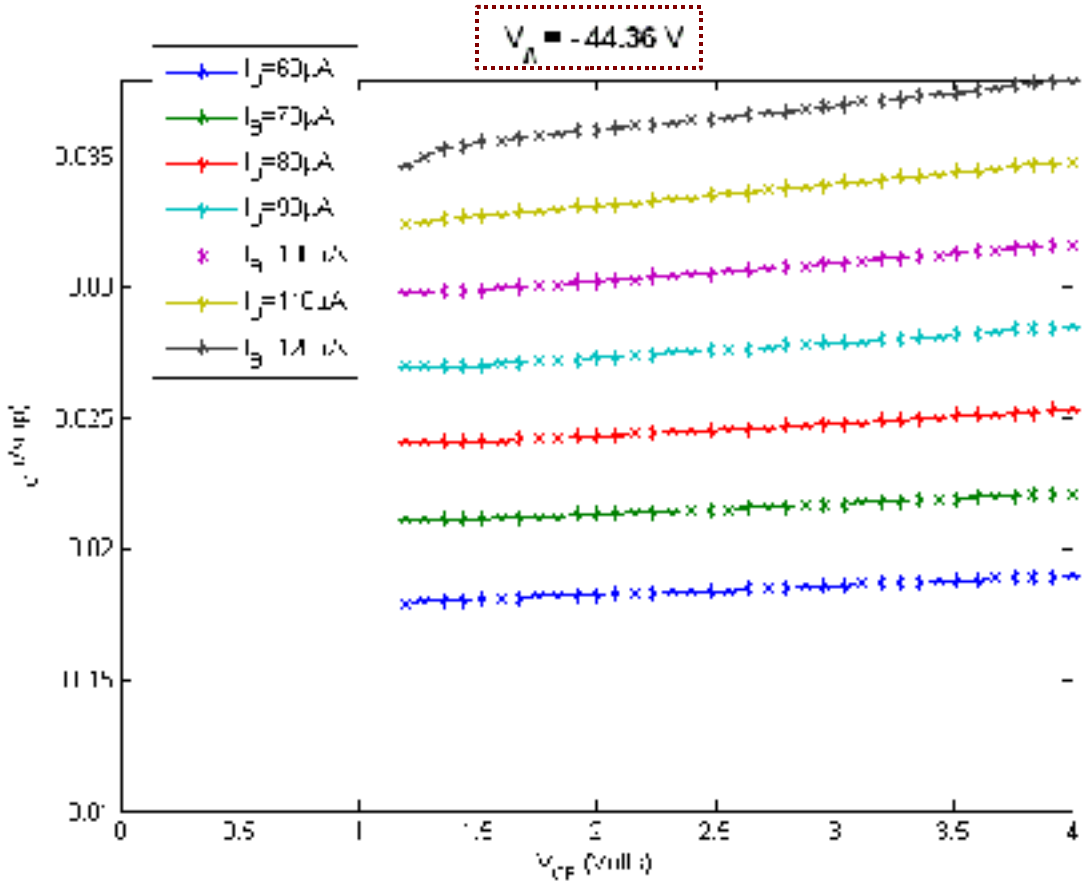
BJT Output Characteristics



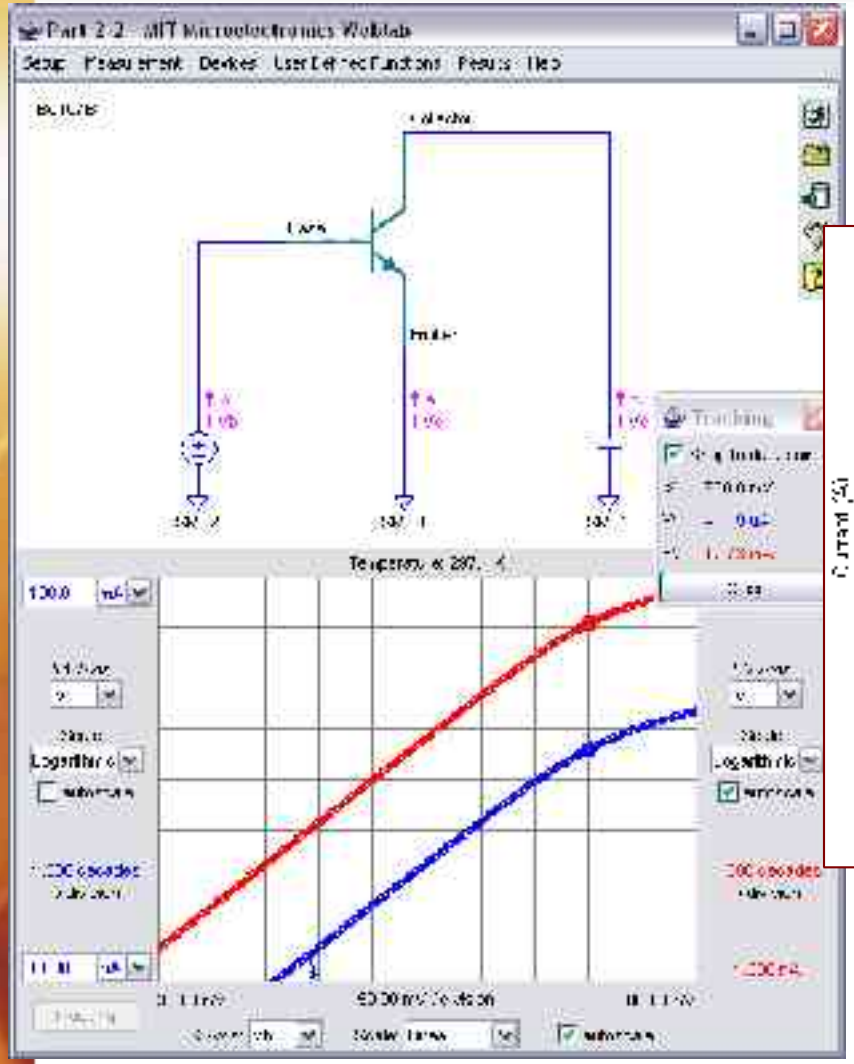


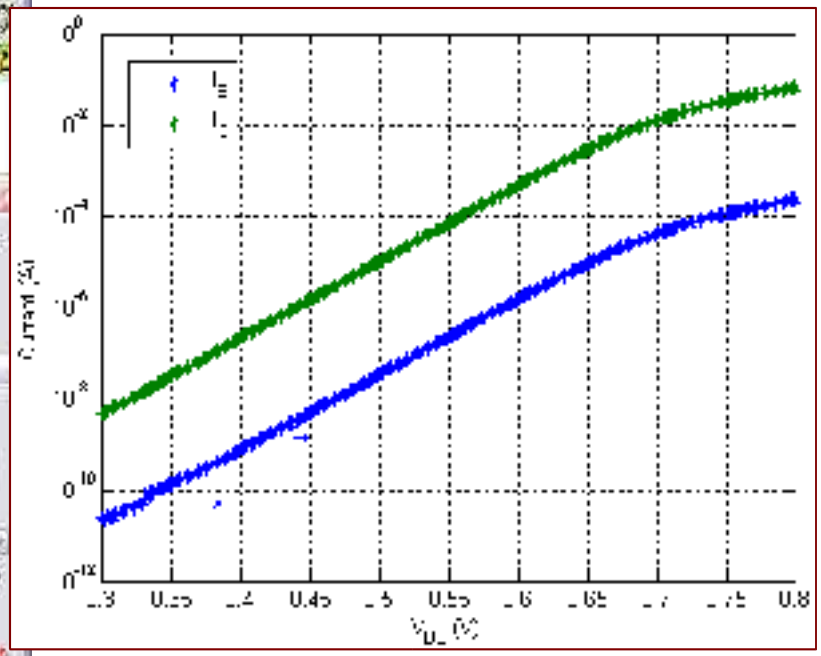
BJT Early Voltage

- Data has been fitted to linear equations using MATLAB & the average x-axis intercept is calculated. The Early voltage is approximately 44.36V

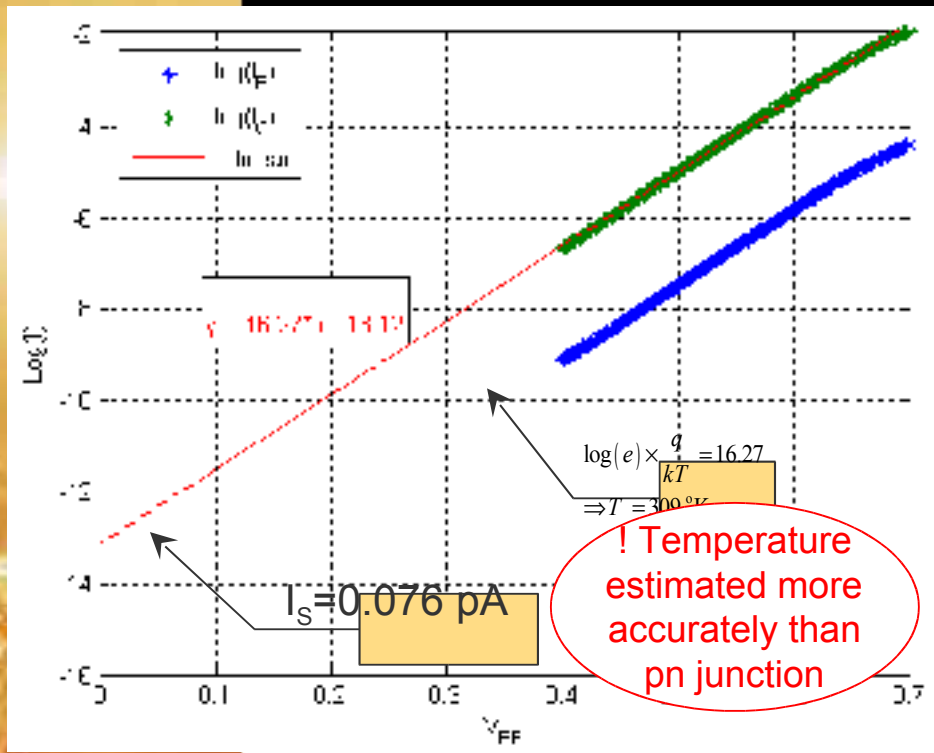


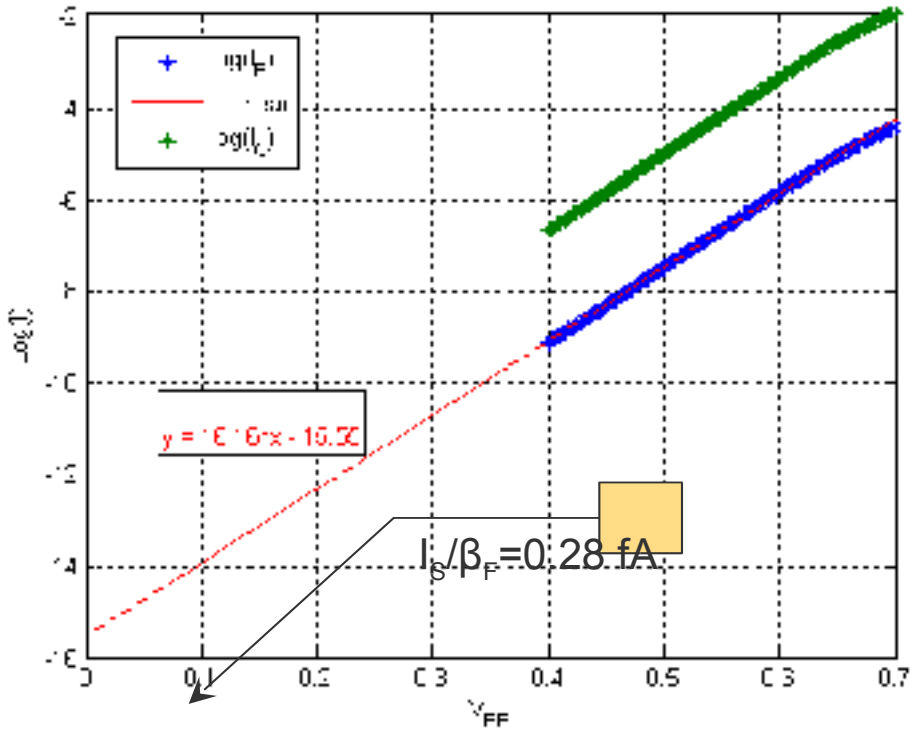
Gummel Plots





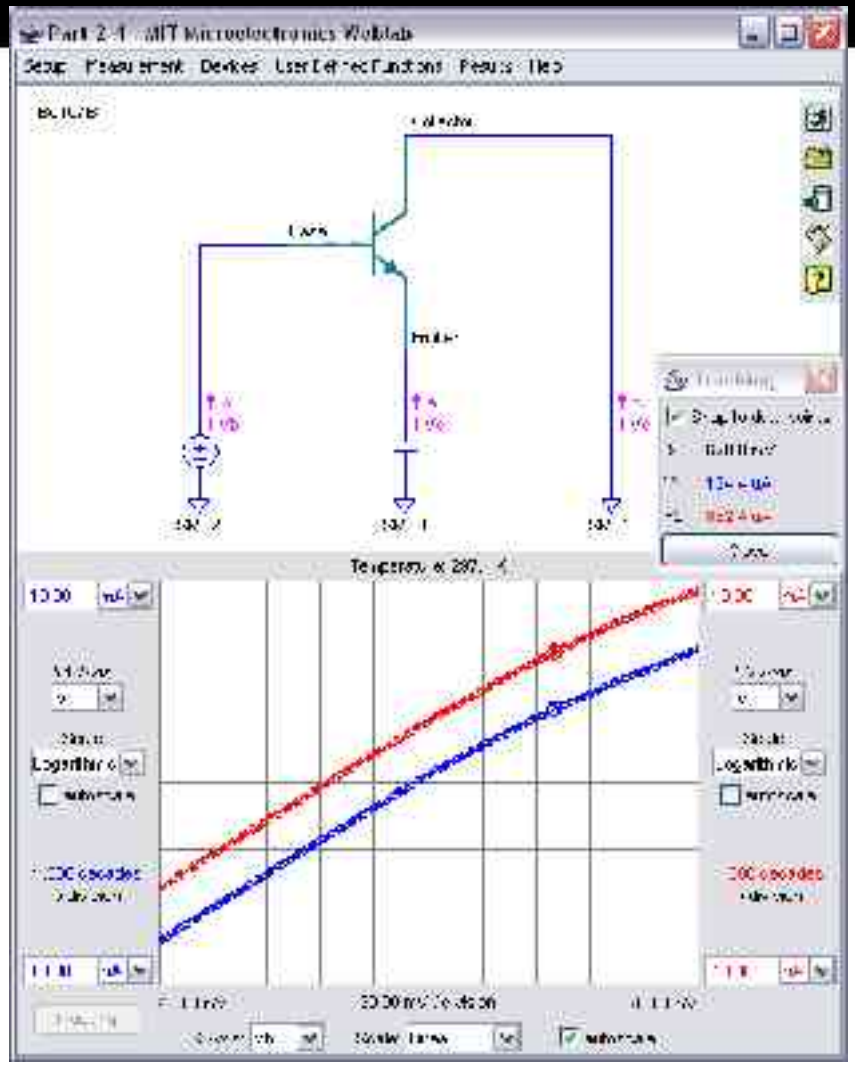
Transistor Parameters



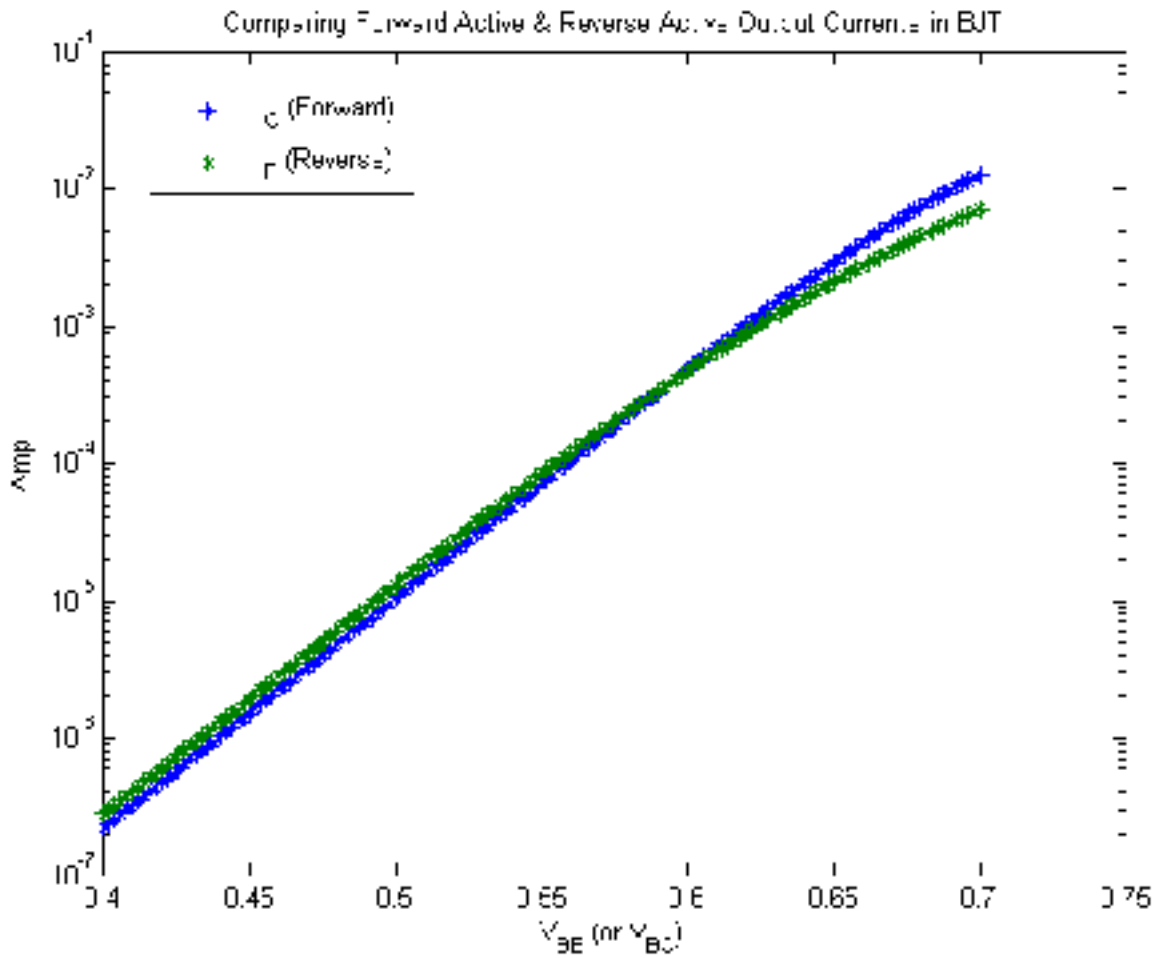


$$\beta_F = 271 \quad \rightarrow \alpha_F = \frac{\beta_F}{1+\beta_F} = 0.996 \quad \rightarrow I_{ES} = \frac{I_S}{\alpha_F} \; ; \; I_S$$

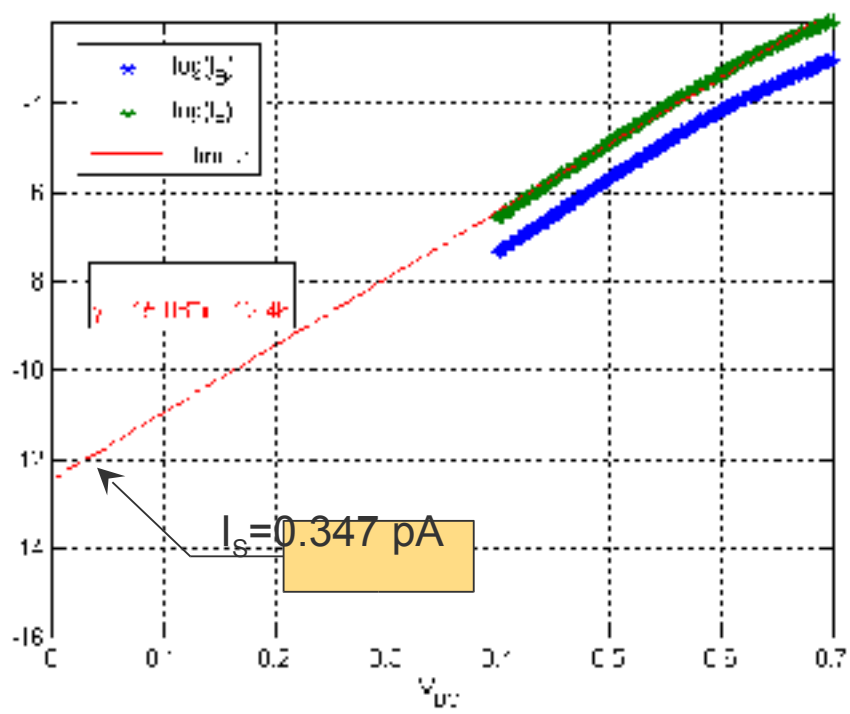
Reverse Active Operation

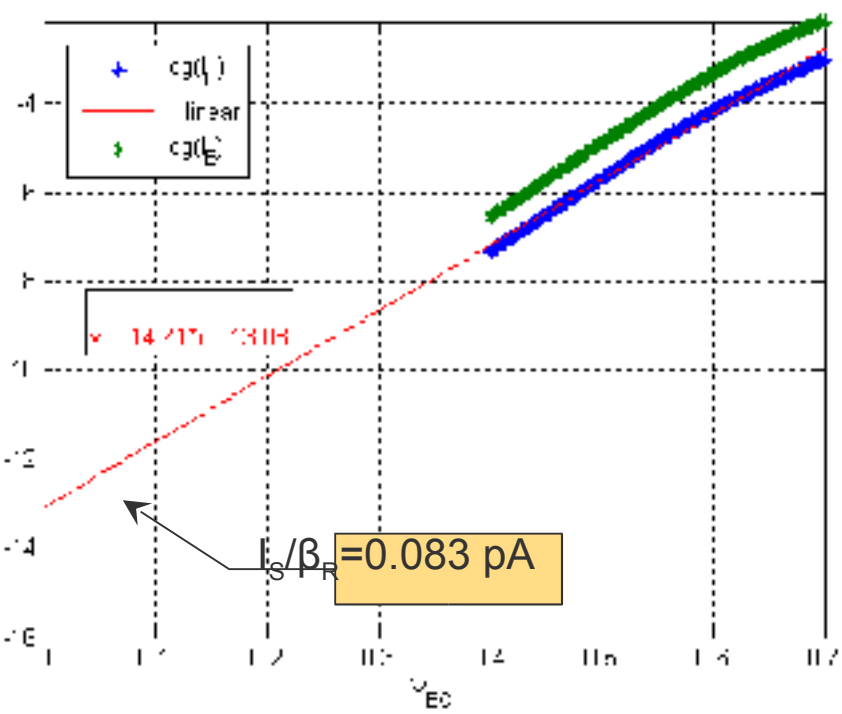


Reciprocity



Reverse Active Operation





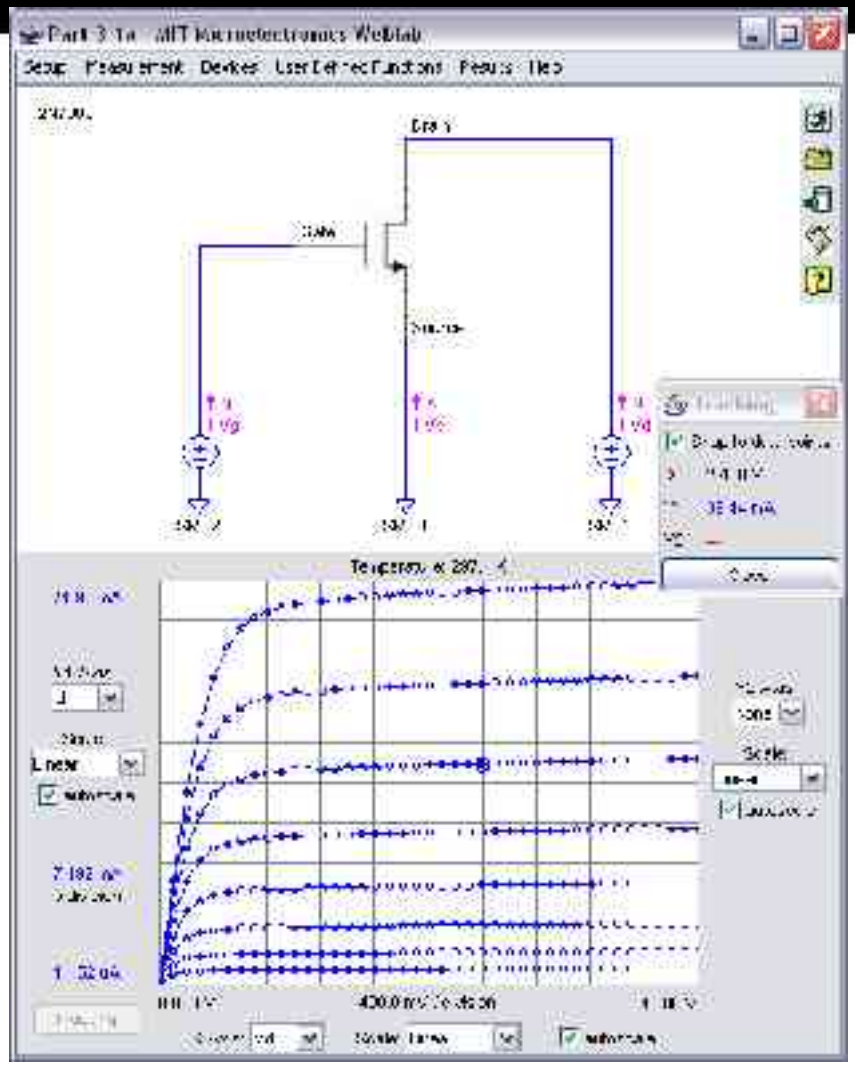
$$\beta_R = 4.18 \rightarrow \alpha_R = \frac{\beta_R}{1+\beta_R} = 0.807 \rightarrow I_{CS} = \frac{I_S}{\alpha_R} = 0.43 \text{ pA}$$

! Small ! Small ! Large

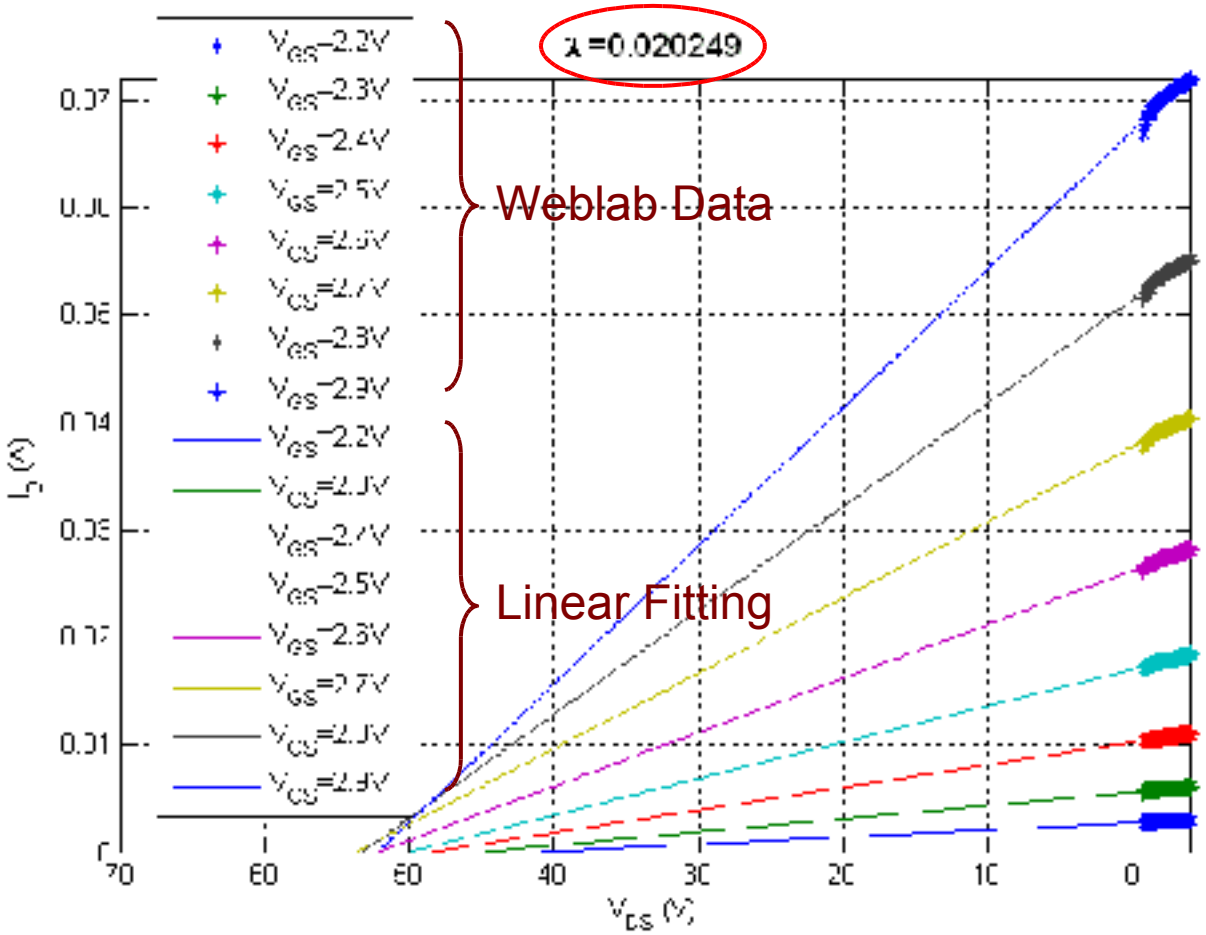
Part 3

N-channel MOSFET

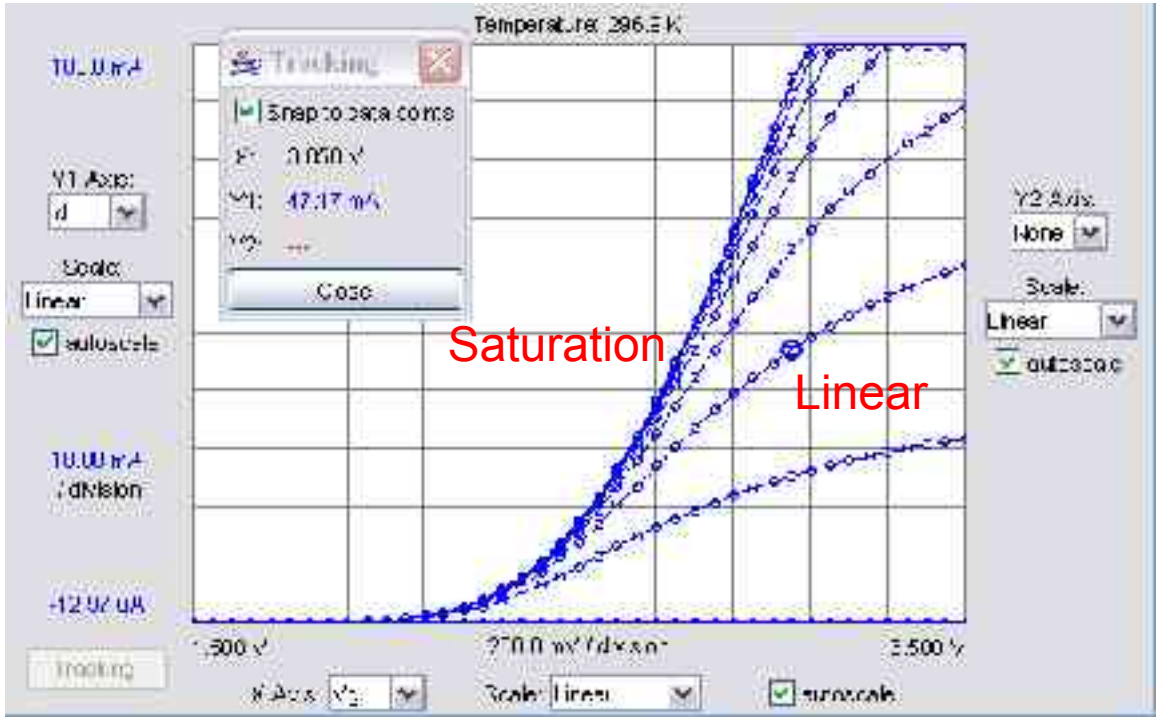
Output Characteristics



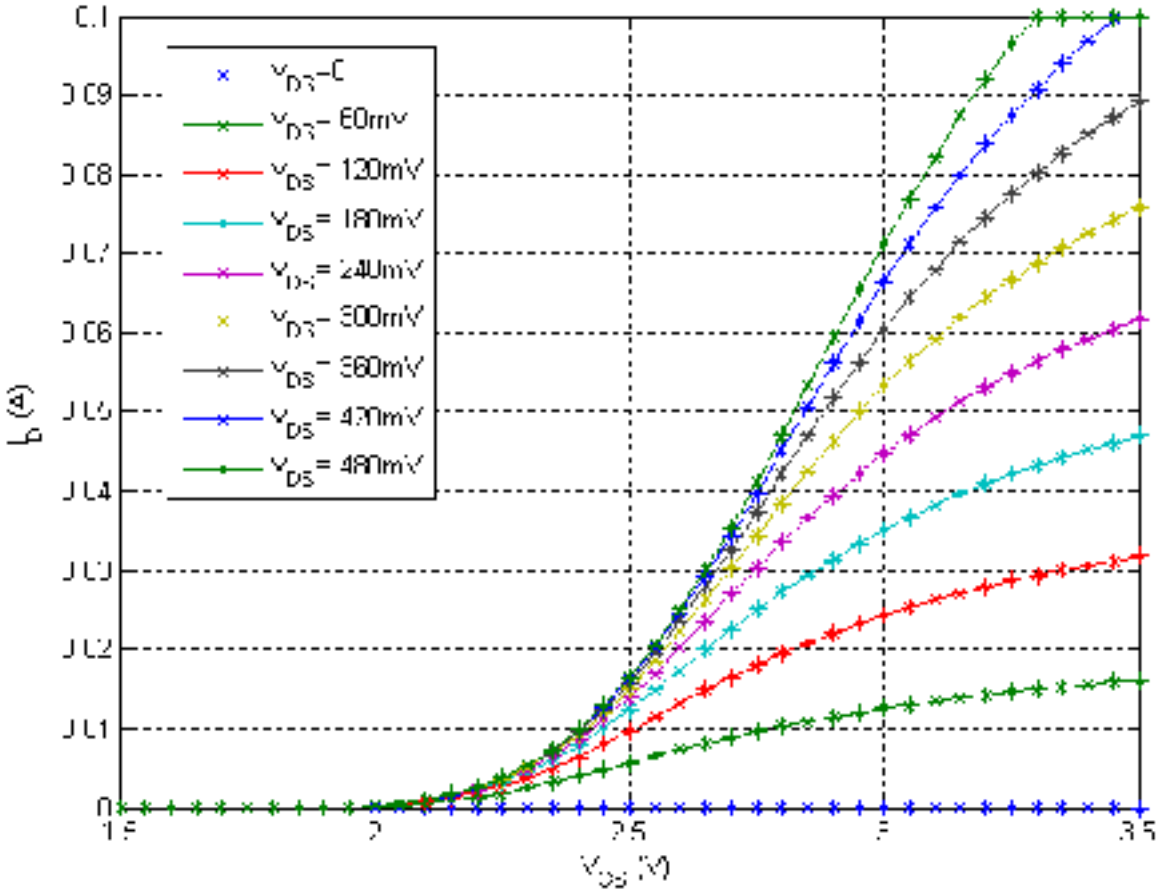
Channel Length Modulation



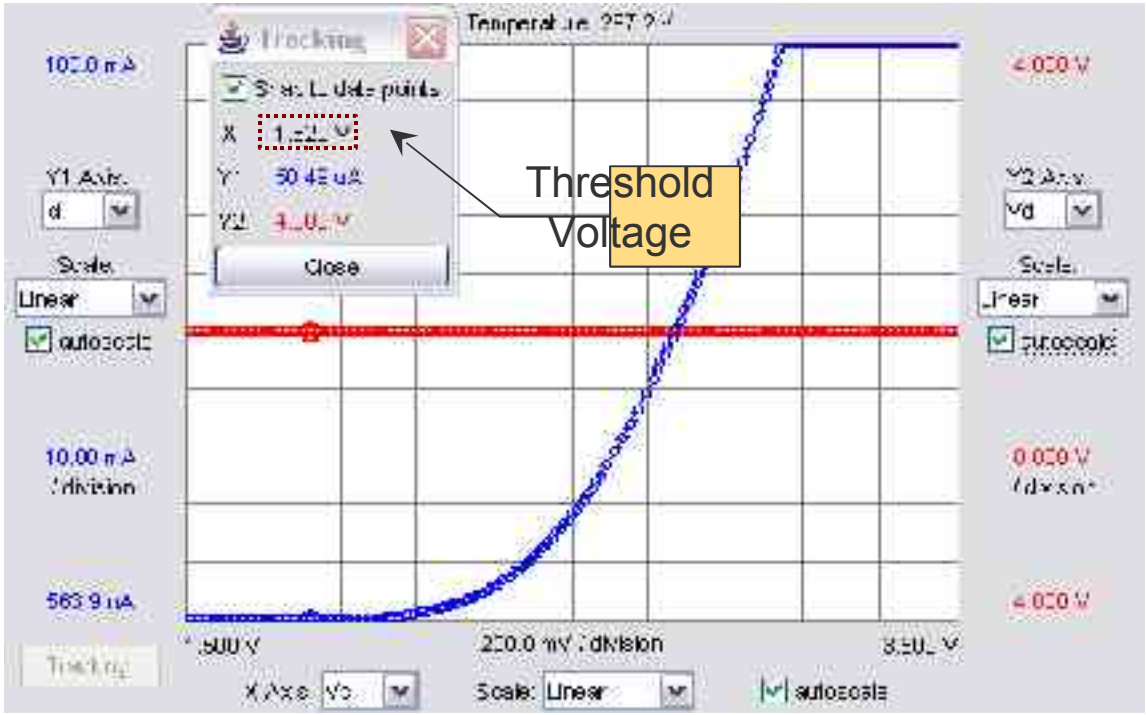
Transfer Characteristics



Transfer Characteristics



MOSFET Parameters



$$\text{Assuming } \frac{W}{L} = \frac{46.5}{1.5} \rightarrow \mu_n C_{ox} = \frac{2LI_{Dsat}}{W\left(V_{GS} - V_T\right)^2} = 1.28 \text{ mA/V}^2$$

Acknowledgement

- Thanks to Prof. M. Ghannam (AUC) for his effort in explaining solid state devices throughout the 551 lectures
- Thanks to Prof. J. del Alamo & Eng. J. Hardison (MIT) for the opportunity they offered to AUC students to explore the MIT Microelectronics WebLab
- Thanks to all 551 class colleagues for the useful discussions we had throughout the Fall-05 semester

Thank You

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