# EE 551 Linear Integrated Circuits
# Project 1
# Curve Fitting and p-n Junctions
# 30 Points

**Objective**
To understand the exponential nature of p-n junctions and how to extract circuit parameters from data using curve fits (especially on exponentials).

**Working Alone for This Project**
Since this project is very short, you will be required to work by yourself. Subsequent projects will require you to work with a partner.

**Data**
The data on the class website are from a voltage sweep of a real p-n junction diode. The first column contains the voltage values, and the second column contains the corresponding current values. *Real data should be plotted as individual data points (such as circles) instead of lines (because we only know the values at those specific points, and not between them). Curve fits and simulation results should be plotted as lines (because they are essentially theoretical expressions).*

**Part 1 – Curve Fitting of p-n Junctions (30 Points)**
- Use MATLAB to create two plots (6pts)
  - A linear-linear plot
  - A log-linear plot (Hint – You cannot display all data in this fashion. Therefore, think about which data you will be able to plot)
  
  Make sure you label your axes appropriately
- Determine the range of voltages over which the p-n junction behaves exponentially and indicate this range *on the plots* themselves. (4pts)
- Perform a curve fit on the data to determine the slope and y-intercept of the data. Assuming that these data were taken under room-temperature conditions (T = 300K), determine both $I_0$ and the ideality factor, *n*. Make sure you include the curve fit line on the above log-linear plot (**always plot the curve fit lines**). Include the values for $I_0$ and *n* on the actual plots. (6pts)
- With your extracted values, write the complete voltage-to-current equation of this p-n junction, replacing the constants $I_0$ and *n* with the values you extracted. Reproduce the linear-linear plot from above, and plot this equation on top of the actual data. *How well does your resulting equation agree with the actual data? If it is not a good match, why not?* (6 pts)
- Please include any other plots or comments that aid in your description of the results. Examples could include zoomed-in plots, etc.

**Thought Questions**
1. Simple diode models describe a diode as being an open circuit below a threshold voltage and a short circuit above a threshold voltage. Is this simplistic description an accurate model of what is occurring (according to the data)? Explain. (3pts)

**Quality of Report (5 Points)**
For this project and all subsequent projects, a portion of the grade will be based upon the quality of the report (i.e. clarity, completeness, neatness, etc.). Please make sure that all numbers are readable, that the figures, text, etc. are large enough, and that there are no gross errors in terms of grammar, spelling or punctuation.

**What to Turn In**
You must turn in a stapled report, as well as an electronic copy of your report which is due at the same time (i.e. at the beginning of class) and should be e-mailed to my address listed on the class syllabus. For later projects, the electronic copy will be very important because electronic files will need to be turned in, as well, including layout, simulation files, etc.

The project report should be written using PowerPoint or an equivalent piece of software (e.g. OpenOffice). An example template for these reports is provided on the class website. The purpose of using PowerPoint is to emphasize succinctness, as well as to enable you to write your reports quickly and easily.

The report should include the following
- A title page with the project number, project title, name/s, and due date
- A Project Objectives slide with the project objectives written in your own words
- As many slides as you need to cover everything described in the project guidelines. These slides should include all data, analyses, and any answers to any questions that are asked. Be sure you answer all questions!
- Slides answering the Thought Questions. Please use a numbering scheme to match the answers to the questions as they are numbered in the project guidelines.
- Conclusions slide where you briefly summarize the project and include any interesting things you learned during the project.

When printing paper copies of your reports to be turned in, you are encouraged to put multiple slides on the same piece of paper. One possible suggestion is to print 6 slides per page, but the rule of thumb is that *everything should be easily readable*. Do not use the "handout" function available when printing since it makes all the slides very hard to see.

**Helpful Hints**
- To learn more about MATLAB functions, type `help function_name` at the prompt.
- There is a MATLAB tutorial on the Links page on the class website.
- The MATLAB functions `polyval` and `polyfit` will likely prove useful for curve fits.
- The following MATLAB commands are useful for creating figures that may be used in your reports.
    - `print -dmeta` → This will copy a figure to the clipboard on Windows computers, which can then be pasted into a Word document.
    - `print -depsc filename` → This will create an .eps file that may be used in LaTeX documents.
- LaTeX Math commands can be used in MATLAB figures to create exponentials, subscripts, Greek letters, etc. Some helpful ones for this and subsequent projects are the following.
    - Exponentials → `x^2` becomes $x^2$
    - Subscripts → `U_T` becomes $U_T$
    - Greek Letters → `\kappa` becomes $\kappa$
- Make sure that you label your axes for all plots that you turn in.
- Point values for each portion of this project have been included in this project description. Future project descriptions may not include such detail, but it has been included in this project description to help you understand how projects will be weighted in the future.