

1 Lab Introduction

In this lab we will be characterizing a diode by measuring its I-V behavior over a very wide range of currents. The learning goals are listed below:

1. Observe the exponential I-V relationship of a diode, appreciate that exponentials change fast.
2. Continue to practice the construction of equivalent circuit models for instrument loading.
3. Observe small signal behavior and contrast it to large signal behavior.
4. Practice analog problem solving and creativity to meet the difficult requirements of the lab

2 Large Signal Diode Characterization

References: *Horowitz and Hill 44-51, Hays and Horowitz Lab Manual 65-74*

1. Measure the current through and voltage across a forward biased 1N4001 diode at current levels that range from 100pA to 500mA. Doing this will require designing a series of measurement circuits, which are deliberately not provided to you so that you have the chance to design them yourself. Consider instrument loading and precision carefully when you make these designs. You may use resistors from the cabinet and the measurement equipment at your station to build the circuits. You can find 1N4001 diodes in the cabinet and may use 1N914 diodes if the 1N4001 are in short supply.

It is possible that you will be interested in using an operational amplifier to make some of the measurements. A few varieties are available in the cabinet and the stockroom. Think carefully before committing to any op-amp based designs: adding op-amps to your measurement circuits can significantly improve your results, but adding them would be an increase in the complexity of your design. It is possible to take all of these measurements without op-amps.

2. Make a log-linear plot of diode current vs. diode voltage. Explain any deviations from a logarithmic (hence linear on your plot) I-V relationship. Extract the saturation current and non-ideality factor of the diode from the plot. Make sure to document any parameter fitting that was required to make the plot. Include only a few (1-3) data points per decade.

Required Data: Schematics of each of your measurement circuits, I-V plot of diode with measured and analytical results overlaid, saturation current and non-ideality factor of diode.

3 Small Signal Diode Characterization

Build the circuit pictured in Figure 1 and drive it with a function generator creating a sinusoid with $V_{pk,pk} = 50\text{mV}$ at an appropriate frequency. Don't forget to model the output resistance of the function generator in your analysis.

1. Plot the amplitude of small signal oscillations, v_{out} , as you vary V_{DD} and R to control I_D . Select a range for I_D that shows interesting features of the v_{out} amplitude vs I_D curve. Make an analytical model of your expected v_{out} amplitude and overlay it on the same plot as your measured data. Be sure to describe your design process for selecting C , the frequency of small signal oscillations f , and your range of I_D .
2. Increase the input amplitude to this circuit until the small signal model fails. Compare traces of a wave which operates in a regime where the small signal model works and one where it fails. Use Fourier analysis to analyze the harmonic content of these waves. Propose a limit on signal amplitude under which small signal models are accurate. It is helpful to watch harmonic content of your waves in real time using the FFT function of the oscilloscope.

Required Data: Plot of v_{out} vs. I_d . Scope traces comparing small signal model working vs. not working. A proposed maximum amplitude for small signals.

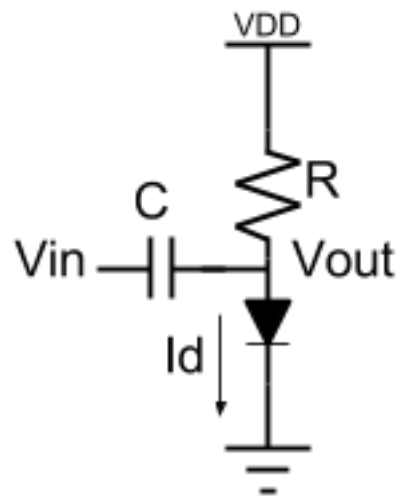


Figure 1: An input signal AC coupled into a resistor diode circuit used for Part 3.