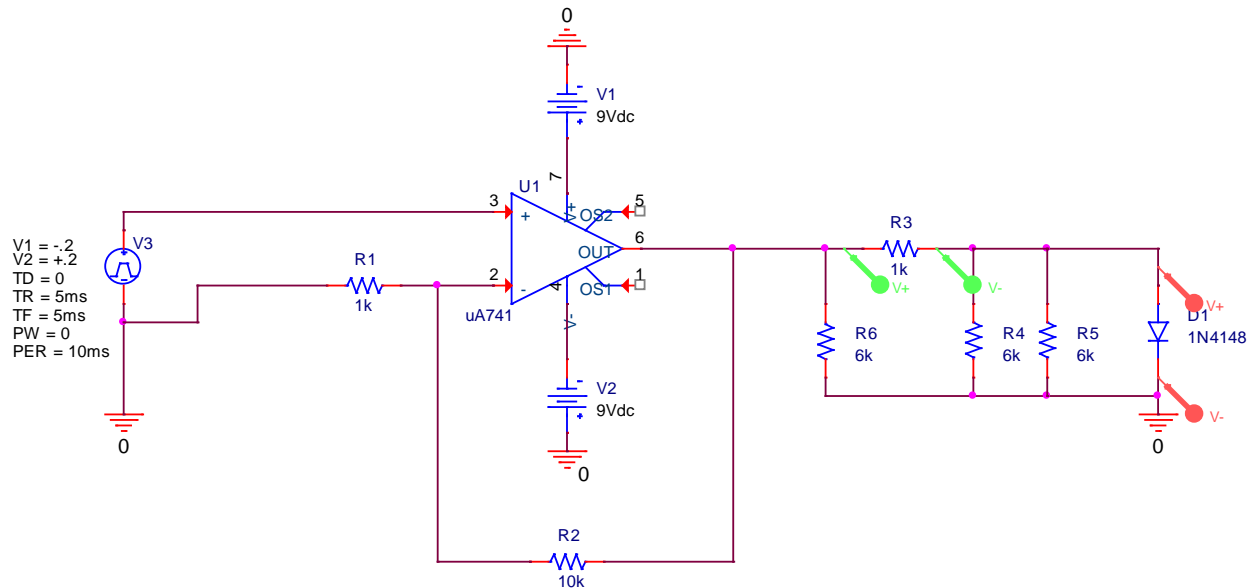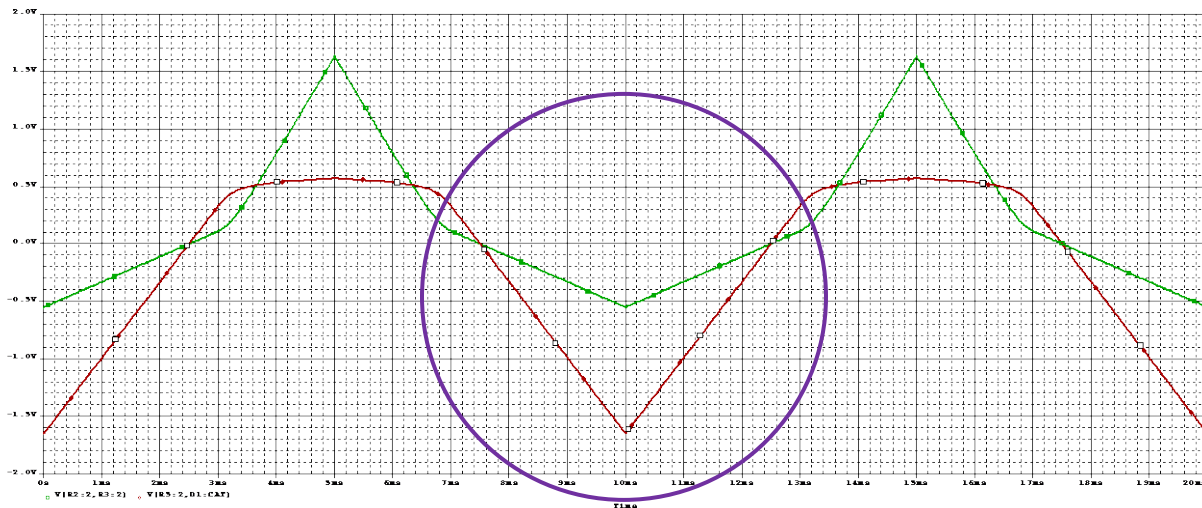Diode I-V Characteristic Set Up Using Larger Voltage Scales on the Mobile Studio

A PSpice simulation of the set up shown in figure A-7


Note the three 6kΩ Ohm resistors placed from the measurement points to ground. These 6kΩ resistors represent the input impedance of the Mobile Studio board.

The output from the simulation looks like the following.

The purple circle shows the problem area. When the diode is reverse biased, it will carry no current. However, the 6k resistors can carry current, which will distort the data. If we replace the 6k resistors with 10 Meg resistors (corresponding to the input impedance of the lower voltage ranges, such as 500mV/div), we get an undistorted picture of what a diode does.
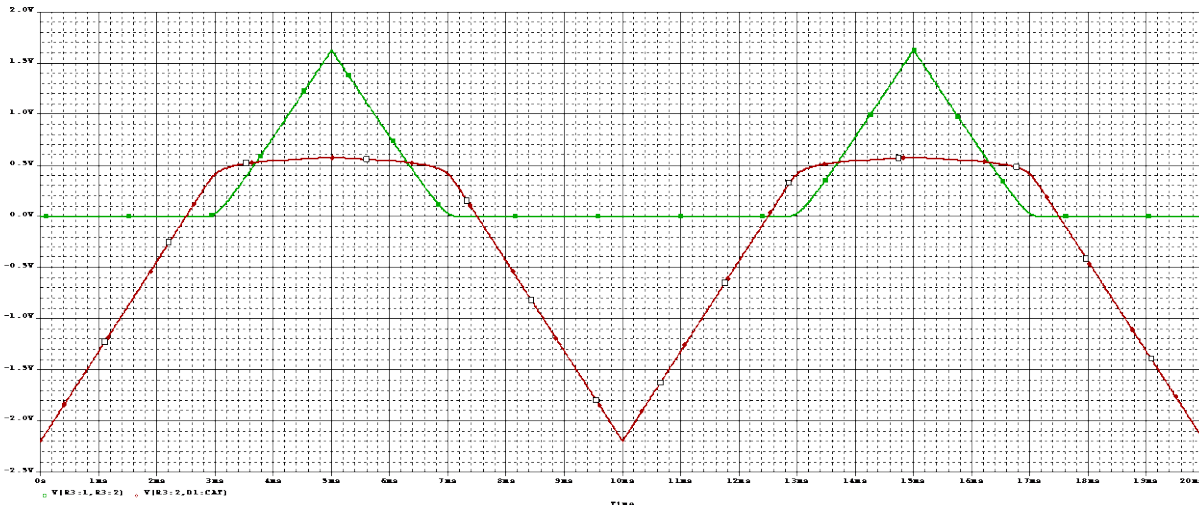
There are two reasons for mentioning this effect. First is to remind us all that measurements affect circuits. Whenever we measure a voltage or current, we must change the circuit in some way. If we do our job well, the impact will be very small so we can neglect it. In this case we cannot, so we have to recognize what is happening when we discuss our data. That leads to the second reason. When you use Matlab to plot your data, you should find that the diode I-V characteristic will not be horizontal, as it should be. Rather, you should notice a significant slope. Measure the slope and see if it is consistent with the input impedance of the IO Board. The next section of this supplement addresses how to modify the Matlab analysis to incorporate the effect of the small input resistance of the Mobile Studio at the high voltage ranges.

Rather than just recognizing the problem with the data, it is relatively simple to modify the Matlab m-file so that the data comes out looking better. In the following, the data from a green LED is analyzed, but the method is exactly the same for the 1N4148 used in Experiment 8. Compare the following m-file to the one in the experiment write-up and you will see what changes need to be made.

```
% LED or Other Diode I-V Plots for Data Taken with Larger Voltages Ranges
% of the Mobile Studio (1V/div or greater).
% K. A. Connor, 27 March 2012


% Import Data From Spreadsheet
% Click on Import Data from the File Menu in Matlab
% Select the CSV File You Stored in the Directory Where This Program is
% Located. Once you have imported the file, type 'whos' to see what the
% default name is for the array with the data in it. It might be 'data' and
% it might be 'untitled.'

% Identify the Time Data
time=untitled(:,1);% The first column is the time vector

% Voltage Data
```

```
v_diode=untitled(:,2);% The voltage across the diode

% Current Data
i_total=untitled(:,3)/1000;% The total current is measured by finding the
voltage across a 1000 Ohm Resistor.

% For the measurement set up in Experiment 8, the input impedance for each
% channel connects the measurement point to ground. Thus, for the higher
% voltage/div ranges (1V/div or higher), with its input impedance of 6k
% Ohms, there will be 6k to ground from both sides of the resistor and the
% diode. For the input side of the resistor, this does not change the
% measurement because the 6k resistor goes to ground. At the output side of
% the resistor, there will be two 6k resistors to ground, one for channel 1
% and one for channel 2. The result is a 3k resistor. The output end of the
% diode is at ground, so the input impedance has no affect there either. To
% find the diode current, it is necessary to subtract the current through
% the net 3k resistor to ground.
i_diode=i_total-v_diode./3000;
% Eliminate current offset;
% i_diode=i_diode+8.3333e-004;
% Eliminate voltage offset
% v_diode=v_diode-0.55;

% Plot the results
plot(v_diode,i_diode,'.');
hold on;
grid;
% axis([-2 4 -1e-3 19e-3]);

% Ideal Diode Equation
is=.5e-15;n=3.3;
vd=[-2:.01:4];
id=is.*(exp(vd./(n.*.0259))-1);
plot(vd,id,'linewidth',3,'color','r');
axis([0 5 0 .01]);
```
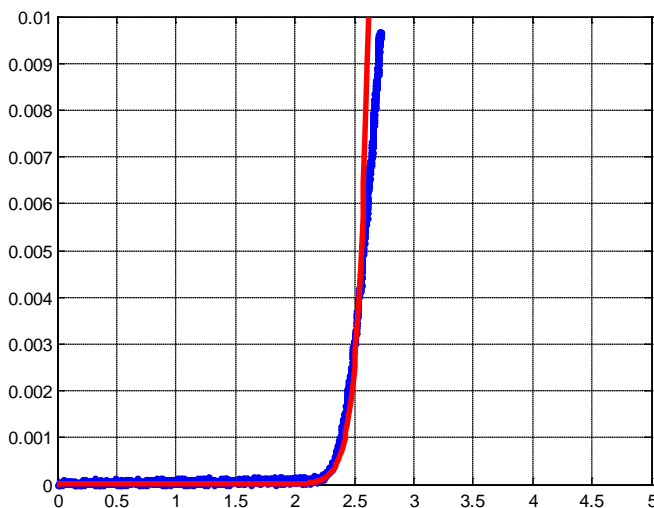

Note that this approach does indeed get rid of the finite slope data in the part of the curve near the horizontal axis. The differences between the measured data and the ideal equation are due to some additional losses that occur in LEDs that we do not see in conventional diodes like the 1N4148.

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For completeness, the plot above is repeated with the raw, uncorrected data added in green. The effect of the small input impedances on the data is clear as is the success of the correction. The corrected analysis shows that it is possible to eliminate artifacts in the data caused by the measurement apparatus, if we have a good model of the devices.