

Massachusetts Institute of Technology  
Department of Electrical Engineering and Computer Science

6.002 – Electronic Circuits  
Fall 2005

Homework 4

Issued 9/29/2005 - Due 10/7/2005

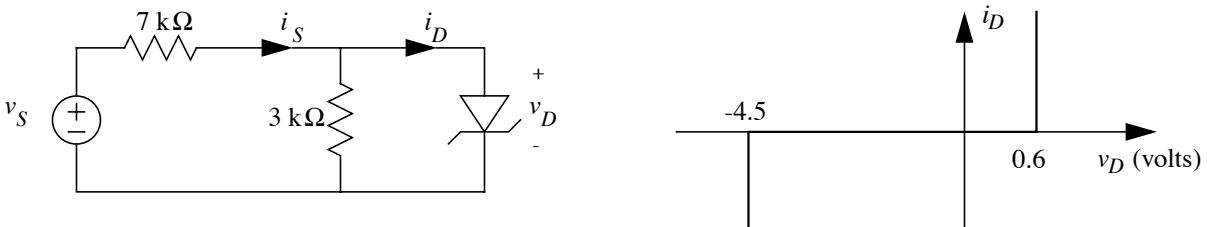
Helpful Readings for this Homework: Chapter 4, Chapter 6.1-6.8

**Exercise 4-0:** Problem 4.4 requires access to Weblab, a remote laboratory. Go to <http://ilab.mit.edu> and click the register here link to get a Weblab account. Account approval may take a couple hours to a day, so register early to avoid any problems with accessing Weblab later.

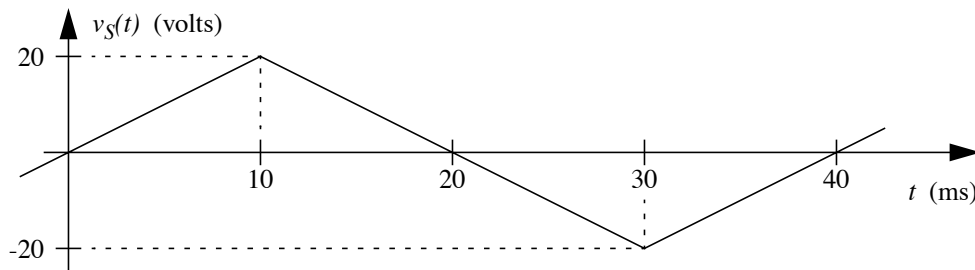
**Exercise 4-1:** Exercise 4.3, Chapter 4, page 231.

**Exercise 4-2:** Exercise 6.5, Chapter 6, page 323.

**Problem 4.1:** The zener diode in the circuit below has the v-i characteristics shown below.



a) For the input voltage  $v_S$  shown below, indicate the time regions where the diode is ON (conducting a current) and OFF (open circuit). Label the boundaries with numerical values.



b) For the input voltage  $v_s$  shown above, sketch the diode voltage waveform,  $v_D(t)$ . Label all breakpoint coordinates with values and units.

c) Find the value of the current  $i_s$  for  $v_s = -25.5$  [V].

**Problem 4.2:** Problem 4.3, Chapter 4, page 233-4. Replace the words "piecewise-linear" with "incremental in parts c) and d), and use the operating point  $v = 3$  [V],  $i = 0$ .

**Problem 4.3:** Problem 4.8, Chapter 4, page 236. For parts a) and b) let  $v_t = 0.025$  [V] .

c) Now that you have determined the optimum value of the resistor, install the optimized system on the rooftop of Building 10. On a mostly sunny day, the presence of clouds in the sky can change  $I_2$  by up to 10 %. Derive an approximate expression that describes the change in power delivered to the resistor due to the change in  $I_2$ . What is the maximum change in power from this approximation?

**Problem 4.4:** For this problem, you will explore Weblab, a remote laboratory that enables you to measure devices from any physical location through a Java-enabled web browser. This remote lab allows you access to more expensive and sophisticated equipment that are not supplied in 6.002 lab. In this problem, we are measuring the current voltage characteristics of a diode using the HP4155B Semiconductor Parameter Analyzer.

- Go to <http://ilab.mit.edu> and login to your account.
  - Select the Microelectronics Weblab Graphical Client.
  - You can click on the Documentation link for more information about Weblab.
  - View the laboratory setting online by clicking the Launch Webcam link. You will see a clock on the top right corner and the HP4155B on the bottom of the screen.
  - Start the lab by clicking the Launch Lab link.
  - If you have trouble running Weblab on a computer, try moving to a different computer or Athena cluster.
  - Direct all questions, problems, or comments with this lab to [6002-weblab@mit.edu](mailto:6002-weblab@mit.edu).
- Experiment Setup:
  - From drop down Devices menu tab select the pn diode device.
  - For this lab, the pn diode has already been connected to the HP4155B through two Source Measurement Units (SMUs). These connections are made in the back of the machine and cannot be seen through the Webcam. SMU 1 is connected to the positive terminal of the diode. SMU 2 is connected to the negative terminal of the diode. The SMUs can source a current or voltage and measure currents and voltages through its terminals.
- Measurement Settings:
  - Click on SMU 1

Name your current and voltage at this terminal and select the download option.

Do a voltage sweep (VAR1) from -1.5 [V] to 1.5 [V] with a 10 [mV] step.

Set the compliance to 10 mA.

– Click on SMU 2

Set this node to ground (COM).

- Run Measurement:

From the drop down Measurement menu tab select Run Measurement.

- Results:

Download current voltage data of the diode onto your local machine. From the drop down Results menu tab select Download Data.

- Questions:

a) Plot and print out the current vs. voltage characteristics of the diode.

b) Calculate the small signal ( $r = \frac{dv}{di}$ ) and large signal ( $R = \frac{v}{i}$ ) resistance of the diode. Plot and print out resistance vs. voltage characteristics of the diode.

c) Comment on the similarity and/or difference of the two plots.

d) How could you do the current vs. voltage measurement of a diode using equipment in 6.002 lab?