III.A. Pre-Lab

You will be measuring several waveforms versus time and several transfer characteristics. All of the measurements can be simulated with PSpice. Read through this lab and identify all of the required plots. Use PSpice to obtain the same plots that you will measure. Paste these plots in your notebook. These plots constitute the pre-lab. For each measurement, your notebook should have a PSpice plot and a scope plot. Compare the plots and make any comments or observations you feel are important.

Some PSpice notes:
- In the Transient Analysis set up, set the maximum step size to 10 μs (10μ in PSpice).
- See Sections 4.D.1 and 6.F.1 of the PSpice manual for examples of plotting transfer curves.
- See Section 6.F of the PSpice manual for an example of generating a plot of a voltage versus time.
- Use parts VTRI, D1N4734A, VDC, and R for the simulations. In the lab you will use a 1N4733A Zener. To get accurate simulations, you will need to modify the BV parameter in the PSpice model and change the breakdown voltage to 5.1 volts.

For each portion of the lab a simulation was set up and ran to plot the voltages $V_{in}$, $V_o$, and $V_r$. A transfer curve of $V_{in}$ vs. $V_o$ was also created.

Data Sheets for the 1N4733 Diode can be found on page 9 of this lab book.
(A) pre_lab_iii_b_vplots-SCHMATIC1-Pre_Lab_III_B_Vplots (active)
(A) pre_lab_iic-SCHMATIC1-Pre_Lab_IICC (active)

-10V
0V
10V

SEL>>

V(VIN) - V(VO)

-10V
0V
10V

V(VO)

-10V
0V

V(VIN)

0s 20ms 40ms 60ms 80ms 100ms

Time
(A) pre_lab_iiic-SCHENMATIC1-Pre_Lab_IIIC (active)
Plots for Illustration (Figure III-9) Symmetrized Zener Diode Clipping Circuit

Voltage Plots

(A) pre.lab.iiid-SCHMATIC1-Pre_Lab_IID (active)
(A) pre_lab_iid-SCHENAMIC1-Pre_Lab_IID (active)

Symmetrical Zener Diode Clipping Circuit

$V_o = V_i - V_T$ (Transistor Curve)
(A) pre_lab_iii-SCHENATIC1-Pre_Lab_IIIE (active)
(A) pre_lab_iiie-SCHMATIC1-Pre_Lab_IIIE (active)

**Profile: "SCHMATIC1-Pre_Lab_IIIE"  [ C:\DOCUMENTS AND SETTINGS\MYERSJP\MY DOCUMENTS\CLASS\ECE_250...**
Date/Time run: 03/26/02 17:13:35
Temperature: 27.0
III.B. Zener Diode Clipping Circuit 1

Wire the circuit of Figure III-1.

Let $V_{IN}$ be a 60 Hz triangle wave with an amplitude of 10 V. Obtain a scope plot of $V_o$ versus time and $V_{IN}$ versus time. Make sure you record all necessary scope settings. Compare this plot to your PSpice plots. Use the cursors or quick measure features of the scope to measure the numerical values where the output waveform is clipped.

Using the procedure developed in Lab 1 for observing I-V characteristics, observe the transfer function of this circuit. A transfer function is a plot of $V_o$ versus $V_{IN}$. To do this you will need to measure $V_o$ with channel 2 and $V_{IN}$ with channel 1, and then change the mode of the scope to XY mode. Note that Channel 1 is displayed on the x-axis and Channel 2 is displayed on the y-axis. You will not need the current sensing resistor as you did in Lab 1 but you will need to use the same scope settings as in Lab 1.

Our PSpice Voltage plot (page 30) match up with our oscilloscope plots from the lab. The $V_o$ vs $V_{IN}$ Transfer curve from the prelab (page 30) match up with the transfer curve from the lab. From the voltage plot the output $V_o$ matches the logic since the Zener diode in the circuit, when forward biased has an voltage of 5.1 volts and a minimum voltage when forward biased of 0.7 volts.

Handwritten note: 9-27-02
Zener Diode Clipping Circuits

Voltage Plots

Vo - Vn Transfer Curve

Slope = \frac{5.42}{5.45} = 0.994
Let $V_{IN}$ be a 60 Hz triangle wave with an amplitude of 10 V. Obtain a scope plot of $V_o$ versus time and $V_{IN}$ versus time. Make sure you record all necessary scope settings. Compare this plot to your PSpice plots. Use the cursors or quick measure features of the scope to measure the numerical values where the output waveform is clipped.

Using the procedure developed in Lab 1 for observing I-V characteristics, observe the transfer function of this circuit. A transfer function is a plot of $V_o$ versus $V_{IN}$. To do this you will need to measure $V_o$ with channel 2 and $V_{IN}$ with channel 1, and then change the mode of the scope to XY mode. Note that Channel 1 is displayed on the x-axis and Channel 2 is displayed on the y-axis. You will not need the current sensing resistor as you did in Lab 1 but you will need to use the same scope settings as in Lab 1.

The voltage plots from the prelab (page 32) agree. The $V_o$-$V_{IN}$ transfer curve predicted in the prelab (page 33) also agrees with our graphs acquired from the lab. The same logic from the previous circuit applies. The only thing different is that the diode is flipped, resulting in the $V_o$ being flipped.
III.D. Symmetrical Zener Diode Clipping Circuit

Wire the circuit of Figure III-3.

Figure III-3: Symmetrical Zener diode clipping circuit

Let $V_{in}$ be a 60 Hz triangle wave with an amplitude of 10 V. Obtain a scope plot of $V_o$ versus time and $V_{in}$ versus time. Make sure you record all necessary scope settings. Compare this plot to your PSpice plots. Use the cursors or quick measure features of the scope to measure the numerical values where the output waveform is clipped.

We would now like to obtain a plot of the resistor voltage $V_R$. This is a difficult measurement because the resistor is not directly connected to ground and scopes measure voltages relative to ground. However we can use the difference function available on the scope to obtain $V_R$. Using KVL we know that $V_R = V_{in} - V_o$. Thus we can measure $V_R$ with the scope by measuring $V_{in}$ with channel 1 and $V_o$ with channel 2 and making the scope display channel 1 minus channel 2. Record the plot of $V_R$ versus time. (We will need to experiment with this measurement a bit. You should be able to display all three traces ($V_r, V_R$ and $V_o$ versus time) on the same scope plot.)

Obtain a plot of the transfer curve, $V_o$ versus $V_{in}$.

Both of our predicted graphs from the prelab (page 34-35) are the same as our graphs acquired from the lab.

The logic of the circuit is that when $V_{in} > 0$, $D_1$ is reverse-biased and the high output is 5.8 V. When $V_{in} < 0$, $D_2$ is reverse-biased and the low output is 5.8 V.
Symmetrical Zener Diode Clipping Circuits Graphs

Voltage Graphs

Vo - Vin Transfer Curve

Agilent Technologies

\[
\text{Slope} = \frac{10.3}{11.25} = 0.91
\]
III. E. Zener Diode Dead-Zone Clipping Circuit

Wire the circuit of Figure III-4.

![Circuit diagram](image)

**Figure III-4: Dead-zone clipping circuit**

Let $V_{in}$ be a 60 Hz triangle wave with an amplitude of 10 V. Let $V_n$ be a 5 V DC source. Obtain a scope plot of $V_o$ versus time and $V_{in}$ versus time. Make sure you record all necessary scope settings. Compare this plot to your PSpice plots. Use the cursors or quick measure features of the scope to measure the numerical values where the output waveform is clipped.

Obtain a plot of the transfer curve, $V_o$ versus $V_{in}$. Be prepared to discuss how $V_o(t)$ or the transfer curve change as $V_n$ is changed.

Once again our Pspice graphs from the prelab (page 34,35) agree with the graphs from the lab. The output $V_o$ can be found by doing plots and the maximum voltage will be $15-5V=10V$. The output maximum voltage will be $5.8V$ when $V_{in} > 0$ and the minimum voltage will be $-5.8V$ and $V_{in} < 0$. As $V_o$ increase the slope of the ends will be steeper and vice versa.
Zener Diode Dead Zone Clipping Circuit Graphs
Voltage BiGraphs

Vo-Vin Transfer Curve

Slope = \frac{4.06}{4.2} \approx 0.96
Summary

The lab did not take long to execute, but was still useful, especially to demonstrate what we have learned in class. The last circuit was pretty difficult to figure out what was actually going on. All of our prelab and lab graphs agreed again. There were no problems that occurred during the lab.

3-28-02