

EE 462G Laboratory # 3

Diode Clipping Circuits

by

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(Lab 2 – Report due at beginning of lab period) (Pre-lab 3 and Lab-3 Datasheet due at the end of the lab period).

I. Instructional Objectives

- Design and implement clipping circuits based on the attributes of semiconductor diodes.

See Horenstein 4.1 and 4.2

II. Transfer Characteristics

This lab introduces simple diode circuits that alter input waveform shapes (wave shaping) and the graphical modeling of their transfer characteristics. Clipping circuits are used to restrict an output voltage to a particular range of values. The output voltage will be proportional to the input voltage as long as the input voltage lies within the desired range. Outside this range the output is clipped (held) to a constant value until the input falls within the “linear” range. In the linear range the output follows the input. The nonlinear switch-like properties of the diode can be used to implement this function. Clipping circuits are used in signal processing applications, radio modulation systems, and power supplies.

III. Pre-Laboratory Exercises

Transfer Characteristic of Diode

- 1) Use previous lab (Lab 2) data plot on the same graph (use different line style to distinguish the plots):
 - a. The measure I-V curve obtain with the curve tracer
 - b. The result of the Shockley diode equation with the best-fit parameters. (Note the diode current can get very large from this equation and cause the plot axis to get so large they obscure the curve tracer data plot. Do not let this happen. Limit the range of the values evaluated on the Shockley equation to those of the curve tracer data so differences between the model and measured data can be seen).
 - c. A vertical line at the forward bias voltage value estimated in the last lab.

This plot can be used for discussing observed results between the predicted and measured results of the clipping circuit. Make sure the axes of the plot are properly labeled.

10 k \square

V_s

V_1

Clipped Sine Wave Generation

- 2) (a) Draw the output waveform for Circuits in Fig. 1a, b, and c for a 1000Hz input sine wave of amplitude 5 Vrms. Let DC sources V_1 and V_2 both equal to 2V, and assume ideal diodes with a forward bias offset voltage that you estimated in the previous lab. (b) For the circuits of Parts (a) draw the transfer characteristic (V_{out} versus V_s) for V_s ranging between -10V and +10V.
- 3) The circuit in Fig. 1b is modified to result in the circuit in Fig. 1d. Describe how the output may change in a practical measurement system as a result of this modification.
- 4) Use SPICE to graph the output of the circuit in Fig. 1c for several periods when V_s is a 5 Vrms sine wave and $V_1=V_2= 2.0V$. Use SPICE to obtain the transfer characteristic of the circuit in Fig. 1c for V_s between -8V and +8V.

Power Distribution

- 5) (a) Determine the average power delivered by the source in Fig. 1a (assume V_s is a 300Hz input sine wave at 5 Vrms). Determine the average power absorbed by the diode and resistor. (b) Repeat Part (a) with each circuit having a 5.1k Ω load resistor.

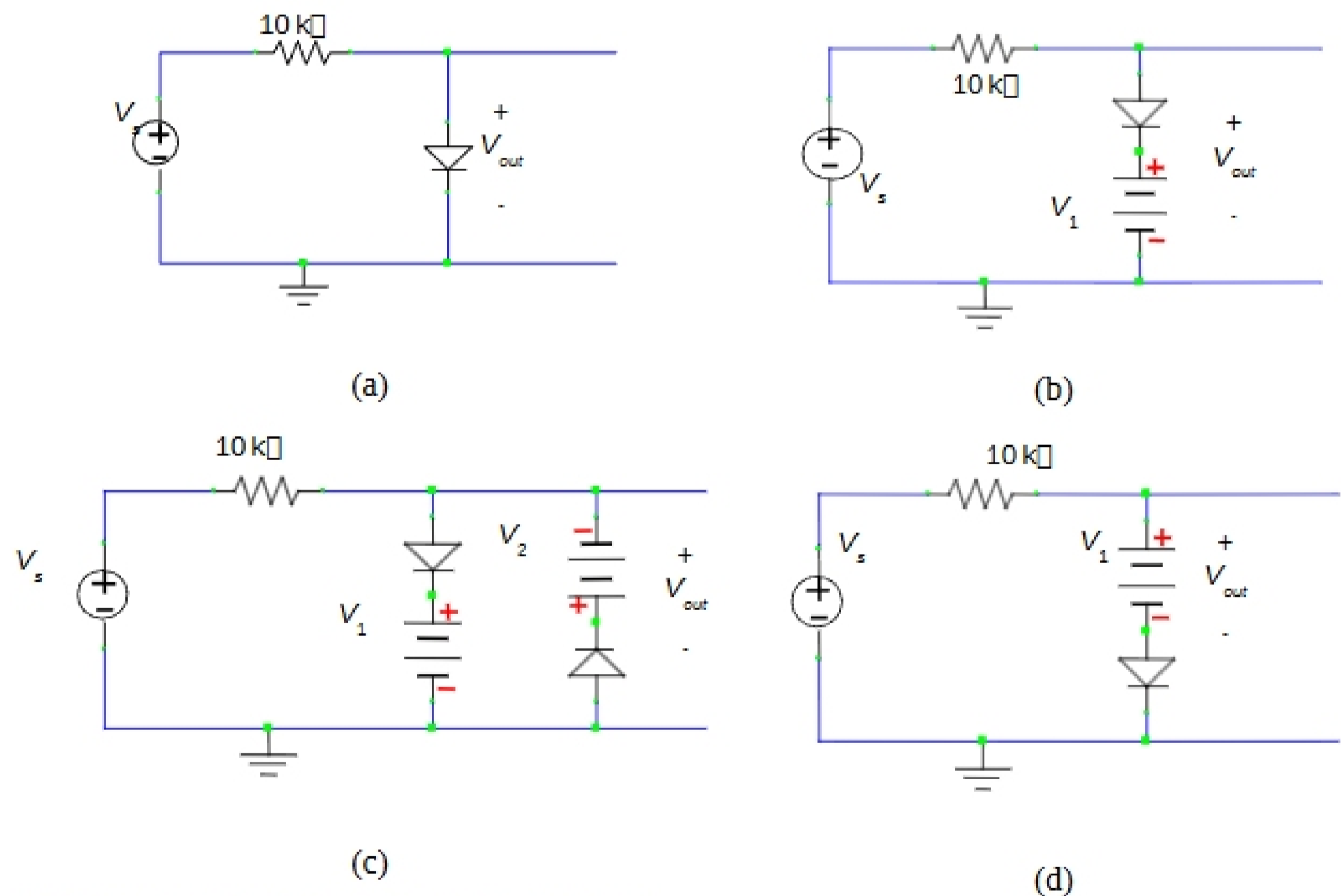


Figure 1. Circuits for analysis and experiment.

IV. Laboratory Procedure

- 1. Generate Clipped Sine Wave:** Assemble clipping circuits of Fig. 1a, b, and c with no load. Connect a 1000Hz, 5Vrms sine wave signal from the function generator for the V_s input and use power supply to make V_1 and V_2 equal to 2 volts. Beware of polarity and ground issues when using the power supply. Be sure the scope is in the Y-T mode (this is set using the scopes display menu) so it will display both the signal on Channel 1 and the signal on Channel 2 versus time. You can display V_s and V_{out} simultaneously using the two vertical scope channels. Record output waveforms for each circuit. Vary the voltages for V_1 and V_2 . Describe qualitatively (in words) how V_1 and V_2 effect the output waveform. **(Discussion: Comment on the observed output waveform. Provide reasons for the result. How does it compare to your pre-lab prediction? Describe the effect of V_1 and V_2 on the output waveform for the circuit of Fig 1c.)** Grounding issues with the power supply should be described in the **procedure section**.
- 2. Measure Transfer Characteristics of Circuits:** Assemble clipping circuits of Fig. 1a, b, and c as in Procedure 1. Change the scope to the X-Y mode. Use the scope to display V_{out} versus V_s (V_{out} on the Y-axis). Adjust the function generator's amplitude to set V_s to a 16 Vp-p sine wave that ranges from $-8V$ to $8V$. Record the trace for each circuit. **(Discussion: How will changing the frequency of input affect the TC curve? How will changing the amplitude of input sine wave affect the TC curve?)**
- 3. Generate Clipped Sine Wave with Load and Compare Power Distribution:** Apply a $5.1k\Omega$ load to the output of the circuit in Fig. 1a, and record the resulting waveform for V_s equal to a 1000Hz, 5Vrms sine wave. Lower the frequency to 300Hz and measure the power delivered by the source, and power absorbed in the resistors and diode. Take the load resistor out and repeat power measurements. The digital multimeter and oscilloscope can be used to measure rms current and voltages in each of the branches so average power can be computed. **(Discussion: Described the change of power distribution as a result of the load. Compare to pre-lab results).**
- 4. Demonstrate Effects of Series Power Supply Placement:** Compare the clipped sine wave outputs for the circuits of Figs. 1b and d as in Procedure 1, except vary the frequency of the sine wave input where differences in the clipped waveform are observed. Use the Labview program "test_use_files_freq.exe" and set the voltage amplitude low enough so it is not clipped. Create a file with range for frequency values such that you see a phase and amplitude pattern similar to what you did in lab 1. Try to find a frequency range where the phase shift passes through the 45 degree point. You will need to do some experimentation to figure out what a good range of frequencies should be for each circuit. Open the file of frequencies you created with the "test_use_files_freq.exe" program, let it run and save the output to a file. Repeat this until you have a range of frequencies with good values that pass through the 45 degree point for each circuit. Apply the program used in Lab 1 to estimate an approximate capacitor values for each circuit. **(Discussion: Explain why capacitance exists in your circuits and explain why this capacitance is different between for the 2 circuits?)**