Fun with Diodes II: Limiting and Clamping Circuits
(See Section 4.6, p. 207 of Sedra/Smith)

OBJECTIVES:

To study diode-based limiting and clamping circuits by:

- Analyzing, simulating, and building several circuits, including peak detectors, clamp circuits, and limiter circuits.
- Noting that many diode-based circuits are easy to assemble, in this lab you will build several circuits that require only a few simple components.
- Using an oscilloscope's X-Y mode to plot output vs. input voltage.

MATERIALS:

- Laboratory setup, including breadboard
- Several junction diodes (e.g., 1N4003) and Zener diodes (e.g., 1N4733A)
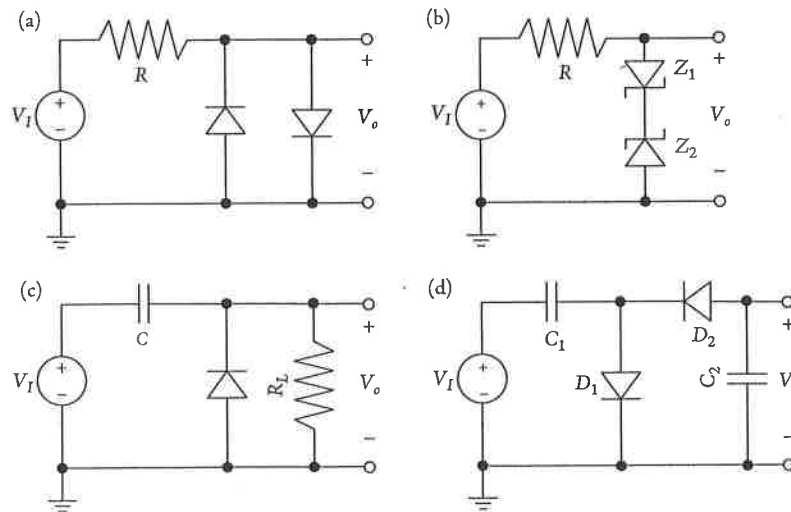- Several wires, resistors, and capacitors of varying sizes

FIGURE L4.3: (a) Limiter, (b) Zener diode limiter, (c) clamping circuit, and (d) voltage doubler. Circuits are based on Figures 4.31 p. 209, Fig. 4.33 p. 212, and Fig. 4.34 p. 212 S&S.

PART 1: SIMULATION

Consider the circuits shown in Figure L4.3(a)–(d). Simulate each circuit with the parameters indicated next. For each simulation, provide a plot of v_I and v_O vs. t.

- Diode limiter (Figure L4.3(a)):
  - o Use $R = 1$ kΩ and 1N4003 diodes.
  - o Simulate using a 5-V_{pk-pk} 100-Hz input sinusoid with no DC component.
  - o Use your simulator's X-Y mode to plot v_O vs. v_I
- Zener diode limiter (Figure L4.3(b)):
  - o Use $R = 1$ kΩ and 1N4733A Zener diodes.
  - o Simulate using a 15-V_{pk-pk} 100-Hz input sinusoid with no DC component.
  - o Use your simulator's X-Y mode to plot v_O vs. v_I
- Clamped capacitor (Figure L4.3(c)):
  - o Use $R_L = 10$ kΩ, $C = 47$ μF, and a 1N4003 diode.
  - o Simulate using a 2-V_{pk-pk} 100-Hz input square wave with no DC component.
  - o What are the highest and lowest voltage values?
- Voltage doubler (Figure L4.3(d)):
  - o Use $R_L = 100$ kΩ across the output $C_1 = C_2 = 47$ μF, and 1N4003 diodes.
  - o Simulate using a 5-V_{pk-pk} 100-Hz input sinusoid with no DC component.

PART 2: MEASUREMENTS

- For each circuit, build the circuit, apply the input waveform specified above using a function generator, and capture the output voltage waveform on an oscilloscope. For circuits (a)–(c), what are the highest and lowest output voltage values?
- For the limiter circuits, use the oscilloscope's X-Y mode to plot v_O vs. v_I.
- Using a digital multimeter, measure all resistors to three significant digits.
- Further exploration I: Can you change the limiting voltages for the first circuit to approximately +1.4 V and –1.4 V?
- Further exploration II: Can you turn the clamped capacitor into a negative clamp?

PART 3: POST-MEASUREMENT EXERCISE

- Do any of your measurement results differ significantly from what you expect and from the simulations? Explain.

PART 4 [OPTIONAL]: EXTRA EXPLORATION

- Can you modify the voltage doubler so it produces a positive output voltage?