Lab 2

Diode Applications

Purpose

In this lab, several applications of the diode will be studied. These include clipping, clamping, demodulating, and full-wave rectifying applications.

Material and Equipment

Oscilloscope
1 - Function Generator
4 - 1N4004 Diodes
1N4148 Diode
Power Supply
Multimeter
Assorted Capacitors
Assorted Resistors

Prelab

a) Review clipper and clamper circuits.

b) Design a clipper circuit which limits input signals to +3V and -2V. This means that the output signal should not rise above 3V and should not fall below -2V. Simulate your clipper in PSPICE to test your design. The input signal should be a sine wave (VSIN in the PSPICE→SOURCE library) with an amplitude of 5V and frequency of 1KHz. Use a 100K resistor. Use a 1N4004 diode. This diode is available in PSPICE as D1N4004 in the diode library (diode.olb). Run a transient simulation up to 5mS. This will show you 5 periods. Obtain the I/O waveforms. Now change the resistance to 100 Ohms and re-simulate. Report the changes that you observed along with explanations for these changes.

c) Design a clamper circuit to clamp the upper limit of the input signal to 0V. Use a 5.1k resistor, a 1N4148 diode. Calculate the value of capacitance required. Show your calculation. Then test your design in PSPICE. Use a square wave input signal of 1.5V amplitude and a frequency of 1KHz. The square wave source is available in the PSPICE SOURCE library as VPULSE. Fill in the following fields as given below

V1 = -1.5, V2 = 1.5, TR(rise time) = 1u, TF(fall time) = 1u, PW(pulse width) = 0.5m, PER=1m

The diode is available as D1N4148.

Run a transient simulation to show 10 periods of the output signal.

Reduce the capacitor by a factor of 5 and repeat the simulation.

Background

The diode has many applications. In this lab, a few of them will be investigated. The first is the clipper circuit. This circuit limits an input voltage to certain maximum or minimum values. In the circuit in Figure 2-1, one can see that as long as Vi is less than 2.5V, then the diode will be reverse biased (an open circuit). In this case, the output voltage will track the input voltage. If Vi exceeds 2.5V then the diode turns on and then Vo will be 5V. Thus, this circuit limits the output voltage to less than 2.5V. By rearranging the components variations on this circuit can be achieved. (See Savant.)

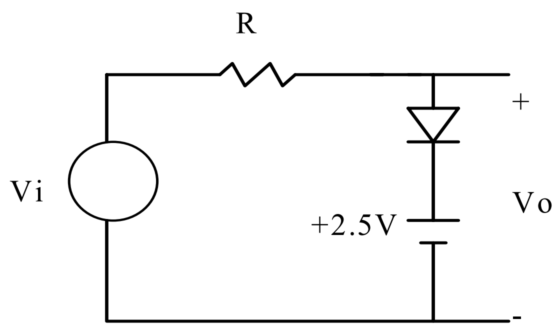

Figure 2-1: Schematic of a clipper circuit.

The next circuit is the clamping current. This circuit works by allowing the capacitor to charge up and act like a battery. This the voltage across the capacitor subtracts from the input signal causing a shift in the reference point of the output. Because the voltage across the capacitor depends on the input waveform, the output maximum (or minimum depending on orientation of the diode) will be clamped to a fixed reference point (in this case, ground potential.) The only design constraint is that $2\pi RC$ be five times larger than the period of the input waveform.

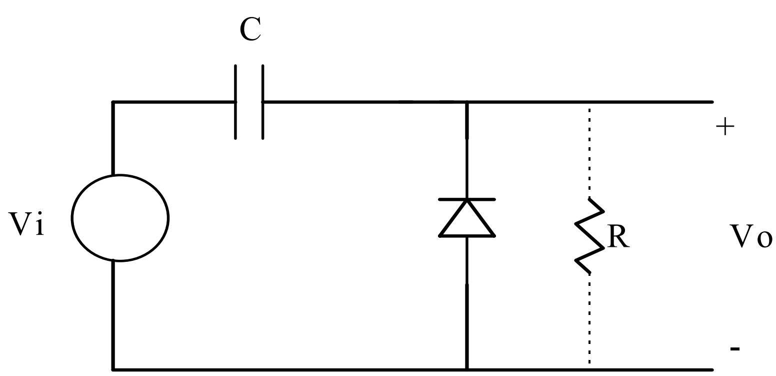

Figure 2-2: Schematic of a clamper circuit.

Finally, the diode bridge can be used to create a full wave rectifier. As opposed to the half-wave rectifier as shown in Figure 1-5, the full-wave rectifier allows both the positive and negative voltage part of a time varying waveform to be transmitted to the output. While the positive part of the waveform remains unchanged from the input to the output, the negative voltage portion is inverted about the time axis, such that the output is always positive.   A complete discussion of the full wave rectifier can be found in Savant. One drawback to the full wave rectifier is that the input and the output voltages have two different references. This is a potential source of grounding problems. One way to rectify this problem is to isolate the input source through a transformer.

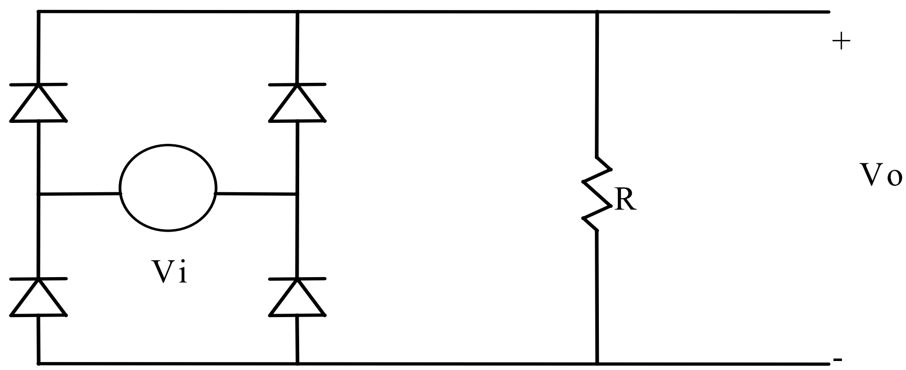

Figure 2-3: Full wave rectification.

Procedure

1) Diode Clipper Circuits

Diode clipper circuits can be used to limit a voltage to some maximum (or minimum value). This useful for designing protection circuits.

a) Connect the circuit in Figure 2-1. Use R = 100 kohms and a 1N4004 diode. For the input signal, use a 10 Vp-p, 1kHz sine wave and use your power supply to provide the battery voltage. Capture the I/O waveforms.

b) Construct the clipper designed in the prelab. Use a 100 kohm resistor to limit the current. Make sure that you take into account the use of real diodes. Drive the circuit with a 10Vp-p sine wave. Capture the I/O waveforms.

2) Clamper Circuits

a) Design a clamper to clamp the upper limit of the input voltage to 0V. Assume that the input signal is 1kHz and that the load is 5.1 kohms. Construct the design circuit and use a 1kHz, 3Vp-p square wave input signal. Use a 1N4148 diode. Capture the input and output waveforms.

b) Lower the load resistance to 100 ohms, measure and capture the output waveform.

c) To the circuit in a) increase the frequency to 10KHz and capture the output.

3) Half-wave Rectifier Properties

Using the circuit from Lab 1 (Figure 1-5), the half-wave rectifying properties of the diode can be displayed. Here we will look at the input and output voltages versus time.

a) Change the resistor in the previous circuit to a 5100 ohm resistor. This will limit the current to very small values. Also use a 1N4004 diode.

b) Set the input voltage source to the circuit to an 8 Vp-p 1 kHz sine wave.

c) Capture the I/O waveforms, the diode voltage, and sketch the resistor current for at least one full period of the input voltage.

4) Full Wave Bridge Rectifier

a) Build the circuit in Figure 2-3. Use 1N4004 diodes. Use a 1kohm resistor to limit the current. Capture the I/O waveforms.

Post Lab Questions

1) As the resistor decreases in value, the performance of the clipper degrades. Explain why.
2) Explain how the clamper performance varies with the following parameters
    a) Frequency
    b) Load resistance
    c) Capacitance

Also explain why it varies the way it does.

3) In both the clipper and the clamper, the diode drop is a problem. Can you suggest a method to reduce the problem associated with the diode drop if not to eliminate it altogether?

4) Mention at least two ways in which the real full wave rectifier you designed in the lab differs from the ideal? What is the reason for these differences.