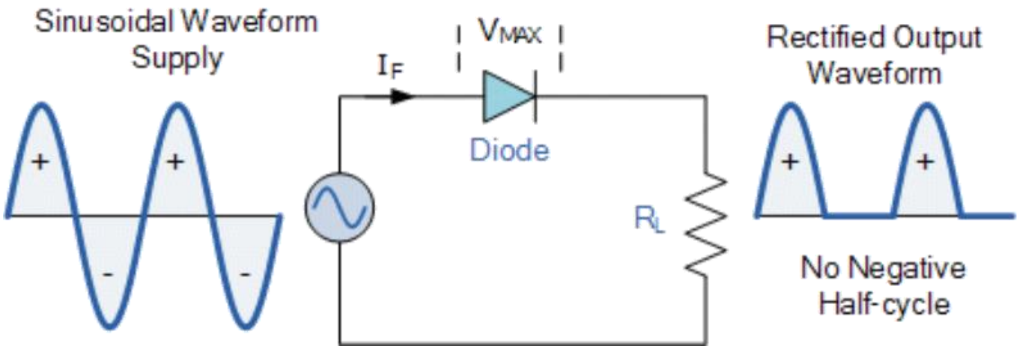
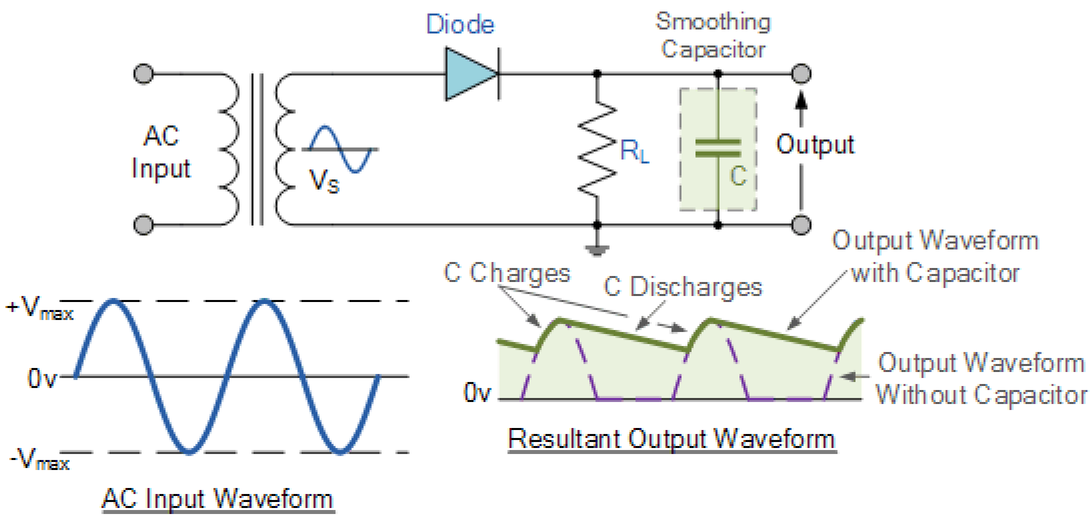
Lab 4.2 – Fun with Diodes 1: Rectifiers

We are going to investigate two common uses of diodes:

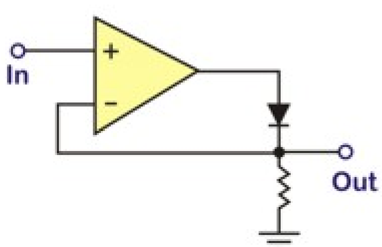
1. The half wave rectifier (the average voltage of the positive sinusoidal pulses – DC value)



2. The "Peak" rectifier that is used to do half wave AC to DC rectification in power supplies where a capacitor is added at the output and the parallel resistor simulates the "load".



The third circuit is a sophisticated use of feedback with an OpAmp to create a "Precision Rectifier". It is not commonly used, but you should try to understand how it works and examine it for any defects from perfection. It relies on "Feedback" an important subject that you will study after "Signals and Systems"



For the "half wave" rectifier, why do the output half sinusoids have a different peak value than the input sinusoid?

In the Peak Rectifier you should examine and discuss:

- The ripple – The variation in the output DC voltage each cycle.
  - Can you estimate the peak to peak ripple as a function of the frequency and the RC time constant? (set the scope to AC so that you can increase the scope sensitivity to see the ripple)
  - What does the power supply current look like per cycle? What problems can this cause?
  - Examine the first few cycles when the system is turned on (most easily done in the simulation). Why does this indicate that turning on a power supply can blow fuses?
- What is the actual DC output voltage when there is a load resistor?

Next semester you will revisit rectification when you will design and build a power supply.

LAB 4.2

Fun with Diodes I: Rectifiers

(See Section 4.5, p. 194 of Sedra/Smith)

OBJECTIVES:

To study diode-based rectifier circuits by:

- Analyzing, simulating, and building several rectifier 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.

MATERIALS:

- Laboratory setup, including breadboard
- Several junction diodes (e.g., 1N4003)
- One 741-type operational amplifier
- Several wires, resistors, and capacitors of varying sizes

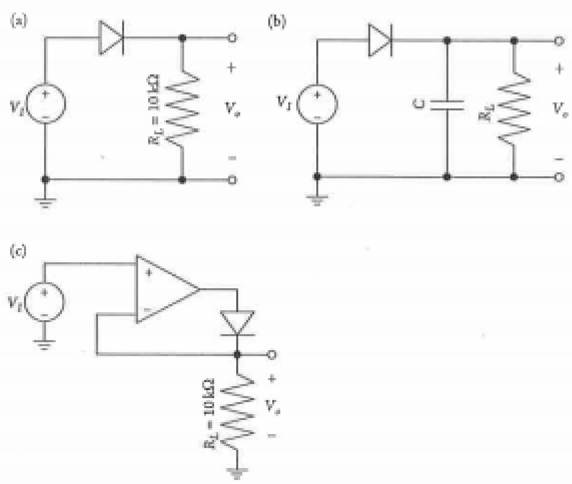


FIGURE L4.2: (a) Half-wave rectifier, (b) peak rectifier, and (c) precision rectifier. Circuits are based on Fig. 4.21 p. 196, Fig. 4.25 p. 202, and Fig. 4.27 p. 206 S&S.

PART 1: SIMULATION

Half-wave rectifier

Consider the half-wave rectifier shown in Figure L4.2(a). Simulate the circuit using a 10-V_{pk-pk} 1-kHz sinusoid and a 1N4003 diode. Provide a plot of v_I and v_O vs. t.

Peak rectifier

Consider the peak detector shown in Figure L4.2(b). Simulate the circuit using a 10-V_{pk-pk} 1-kHz input sinusoid for the two following sets of parameters. For both simulations, provide a plot of v_I and v_O vs. t, and report the peak voltage (V_p) and the ripple voltage (V_r).

- Peak detector I: Use $R_L = 1\ \text{k}\Omega$, $C = 47\ \mu\text{F}$, 1N4003 diode
- Peak detector II: This time use $R_L = 100\ \Omega$, $C = 47\ \mu\text{F}$, 1N4003 diode

Precision rectifier

Consider the precision rectifier shown in Figure L4.2(c). Simulate the circuit using a 10-V_{pk-pk} 1-kHz sinusoidal input, a 741 op-amp, and a 1N4003 diode. Provide a plot of v_I and v_O vs. t. Use $R_L = 10\ \text{k}\Omega$.

PART 2: MEASUREMENTS

- For each circuit, assemble the circuit, apply the required waveform using a function generator, and capture the input and output voltage waveforms on an oscilloscope.
- For the peak rectifier, record the values of V_p and V_r.
- Using a digital multimeter, measure all resistors to three significant digits.

PART 3: POST-MEASUREMENT EXERCISE

- Using your measured resistor values, resimulate your circuits. How do the updated results compare with your simulations, and experiments? Explain any discrepancies.
- What conclusions do you draw from the two different peak rectifiers?

PART 4 [OPTIONAL]: EXTRA EXPLORATION

Can you turn the precision half-wave rectifier into a precision peak rectifier?