Intro to Measurement Systems - Practice 2
Diode Rectifiers and Peak Detectors

LA-CoNGA physics

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1   Objective:

The objective of this lab activity is to investigate half wave and full wave diode rectifiers used to convert AC to DC. These circuits are also used as signal peak detectors and envelope detectors in instrumentation.

2   Background:

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The reverse operation is performed by the inverter.
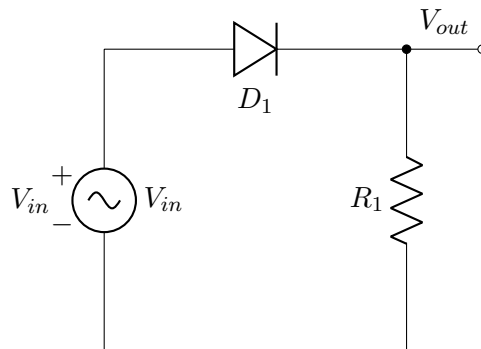

Figure 1: Half-wave rectifier using one diode

Rectifiers have many uses, but are often found serving as components of DC power supplies and high-voltage direct current power transmission systems. Rectification may serve in roles other than to generate

direct current for use as a source of power. As noted, detectors of radio signals serve as rectifiers. In general a rectifier is used to measure the peak value of a signal and is commonly used in particle detection.

In half-wave rectification, either the positive or negative half of the AC wave is passed, while the other half is blocked. Because only one half of the input waveform reaches the output, it is only 50% efficient if used for power transfer. Half-wave rectification can be achieved with a single diode in a single phase supply as shown in figure 1. The output DC voltage of a half wave rectifier, given a sinusoidal input, can be calculated with the following ideal equations:

$$V_{out} = \frac{1}{\pi} \int_0^\pi V_{peak} \ sin(t) \ dt = \frac{V_{peak}}{\pi} \tag{1}$$

$$V_{peak} = \sqrt{2} \cdot V_{rms} \tag{2}$$

Where V_{rms} *is the root mean square* value.

A simple peak detector circuit is a modification of a half-wave rectifier where a capacitor is added after the diode as shown in figure 2
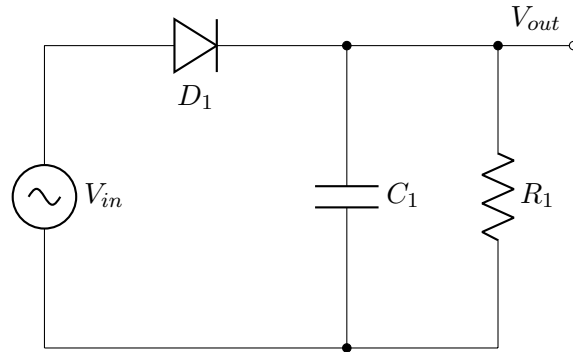

Figure 2: Simple peak detector circuit

Charging time constant of C_1 is:

$$t_1 = r_{df} \cdot C_1 \tag{3}$$

Where r_{df} is the resistance of the diode when is forward biased. Discharging time constant of C_1 is:

$$t_2 = R_1 \cdot C_1 \tag{4}$$

Since $r_{df} << R_1$ two constants are slightly different, this fact limit the maximum frequency at which the peak detector can work.

This is the case for a sinusoidal wave but a peak detector is commonly used to detect peaks of square waves, sensors or modulated signals.

3 Prelab

3.1 Simulating

1. Half-wave rectifier: Perform a transient simulation of the half-wave rectifier of figure 1, using a sine wave of $2V_{pp}$, a small signal diode (1N914 for example) and $R_1 = 100\Omega$. Calculate the following

   - The voltage difference between V_{out} and V_{in}
   - The time delay of V_{out}
   - The power delivered to R_1

2. Simple peak detector: Add a $100\mu F$ capacitor as shown in figure 2 and:

   - Compute the voltage ripple:
   $$V_{ripple} = \frac{I_1}{fC_1} \tag{5}$$
   Where I_1 is the current flowing trough R_1, f is the frequency of the signal in Hz and C_1 is the capacitance in F.
   - Change the value of R_1 with 50Ω, $1K\Omega$, $10K\Omega$ and calculate the ripple again.
   - Calculate t_1 and t_2 for all the cases above

3.2 Questions

Answer the following questions:

1. What happens if the direction of the diode is reversed in both circuits?

2. In the half-wave rectifier explain why is there a difference between V_{in} and V_{out} amplitude?

3. Use a PWL text file (see ref. 5) to load a custom signal as in figure 5 and test the peak detector. Measure the difference between input signal and detector output and count the pulses missed.

4. For the simple peak detector circuit change the diode for a 40V Schottky diode and repeat the simulations

4 Practice

1. Half-wave rectifier: Perform the same measurements done with your simulated circuit. Figure 3 shows the connections of the scope channels in the actual circuit.
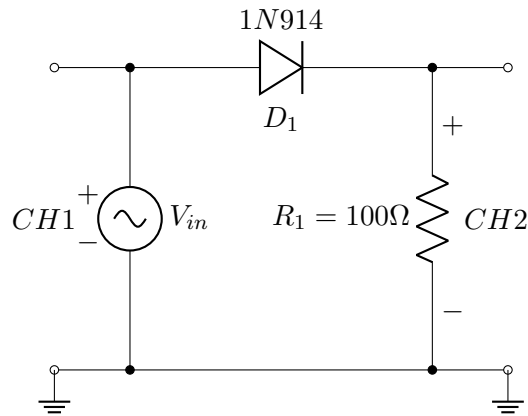
Figure 3: Half-wave rectifier mounted for measurements

2. Simple peak: Perform the same measurements done with your simulated circuit.
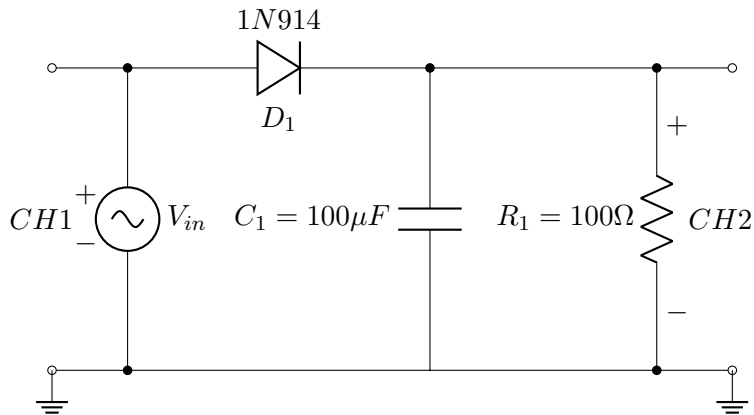

Figure 4: Simple peak detector actual circuit

5   Questions

1. Compare the results of simulations and measurements and draw conclusions

2. In the half-wave rectifier explain why is there a difference between V_{in} and V_{out} amplitude?
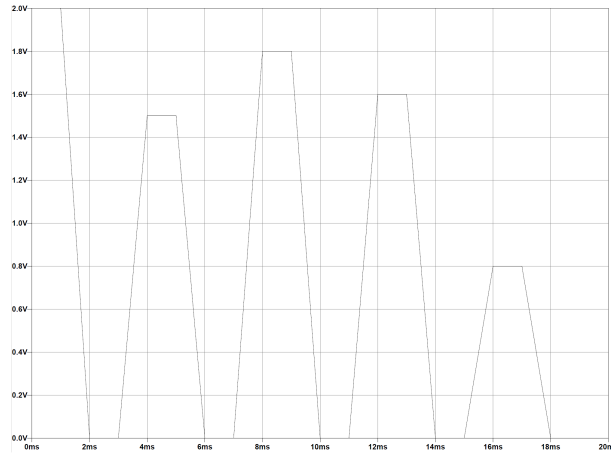
Figure 5: Waveform to test peak detector circuit

6 References

- Half-wave rectifier

- Peak detector

- Importing & exporting data to LTSpice