Lab 5: Introduction to Diodes

Goal

The goals include apply resonant circuit to find fourier components of a square wave and rectification using diodes.

Objectives

1. Construct half-wave and full-wave rectifier
2. Reduce ripple amplitude in a full-wave rectifier using a capacitor

Expectations

1. You are expected to take detailed notes during each step outlined in the procedure that can be used during the lab report write-up.
2. You are expected to provide a neat table of the data that you measured where you clearly label what each data set is and include units for all measured quantities.
3. You are expected to clearly record the measured values of any components that you use.
4. You are expected to clearly record the detail related to images captured by the oscilloscope.
5. You are expected to make your final plots in a program such as Excel. Make sure that your data points appear clearly on the plots, that all axes are clearly labeled and have units.
6. If it is possible to compare your measurements with an expectation or a prediction, you are expected to do so in your lab report
7. You are expected to answer the questions encountered in this manual as well as discuss exercises given during the lectures in your lab write up.

Introduction to Concepts

Rectification using Diodes

A rectifier changes ac to dc; this is one of the simplest and most important applications of diodes (which are sometimes called rectifiers). The simplest circuit is called half-wave rectifier and it is shown in the Figure 1-Left. For a sine-wave input that is much larger than the forward drop (about 0.6 V for silicon diodes, the usual type), the output will look like that in Figure 1-Right. This circuit is called a half-wave rectifier, because only half of the input waveform is used.

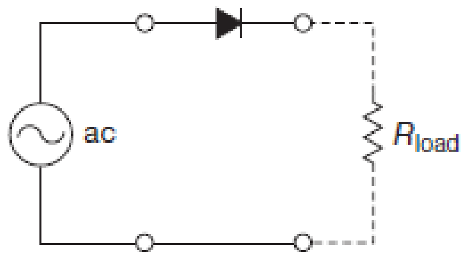


Figure 1.56. Half-wave rectifier.

Figure 1.57. Half-wave output voltage (unfiltered).

Figure 1: Left:The Half-wave rectifier. Right: Half-wave output voltage (unfiltered) [1]

Another rectifier circuit, a "full-wave bridge" is shown in Figure 2-Left. This circuit utilizes the entire input waveform as shown in Figure 2-Right. The gaps at zero voltage occur because of the forward voltage drop of the diode.

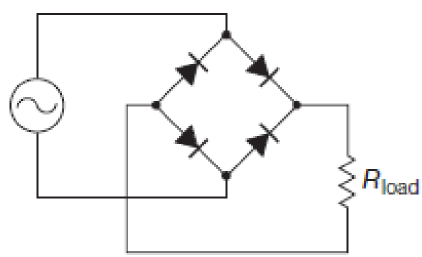


Figure 1.58. Full-wave bridge rectifier.

Figure 1.59. Full-wave output voltage (unfiltered).

Figure 2: Left:The full-wave rectifier. Right: full-wave output voltage (unfiltered) [1]

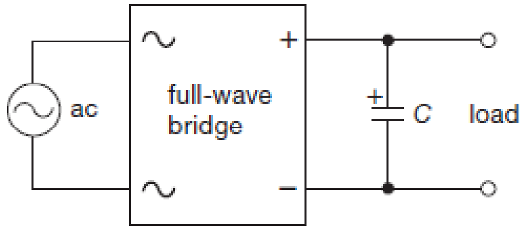
Power-supply filtering

The rectified waveform from a full-wave rectifier cannot be considered complete DC signal due to ripples in the waveform (Figure 2-Right). It is a DC signal only because they don't change polarity and they still have a lot of "ripple" (periodic variations in voltage about the steady value) that has to be smoothed out in order to generate genuine DC signal. This is done by attaching a relatively large value capacitor (Figure 3) which charges up to the peak output voltage during the diode conduction, and its stored charge ($Q = CV$) provides the output current in between charging cycles.

Preliminary Lab Questions

You will find useful to complete the preliminary lab questions before starting the procedure.

1. Write the equation that relates ripple voltage (ΔV to capacitance, C for give ripple frequency (f) and maximum output current (I_{max})?



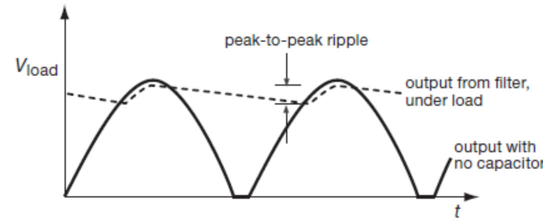


Figure 1.61. Power-supply ripple calculation.

Figure 3: Left:The full-wave rectifier now with a capacitor connected. Right: Full-wave output voltage after the capacitor connected [1]

2. Find the forward bias voltage for the diode used in the lab using it's specification published by the manufacturer?

3. Find the maximum forward current limit for the diode used in the lab using it's specification published by the manufacturer?

Equipment and Parts

1. Signal generator (Instek GFG-8216G)
2. Oscilloscope (RIGOL DS11002E)
3. Multimeter
4. RLC meter
5. proto-board

You will also need the following components in order to carry out this lab.

1. Two pairs of crocodile cables
2. Connecting wires (4 - 6)
3. Two BNC to crocodile cables
4. 22 μF, 470 μF, 1000 μF, and 2200 μF capacitors one each for the rectification circuit
5. Additional 1000 μF capacitor for dual-polarity supply
6. 4 1N4004 diodes for the rectification circuits
7. one 1 or 5 KΩ resistor for the load in the rectification circuits
8. 110 V to 6.3 V transformer for the source of the rectification circuits

Procedure

Rectification using Diodes : Half-Wave

- **Important:** Set the oscilloscope channels to "DC" mode
- Build the half-wave rectification circuit shown in the Figure 1
- Connect input and output signals to the oscilloscope channels 1 and 2, respectively
- Use one secondary coil (yellow and black pair) of the transformer as the AC signal source. The black wire is the ground terminal.
- Connect to 110 V main supply
- Capture input and output signals
- Measure forward-bias voltage drop of the diode using the oscilloscope channels.
- Compare your measurement with the specification published by the manufacturer.

Rectification using Diodes : Full-Wave

- **Important:** Set the oscilloscope channels to "DC" mode
- Build the full-wave rectification circuit shown in the Figure 2
- **Important:** Due to grounding issues you will not be able to observe input and output signals simultaneously for the full-bridge circuit.
- Use one secondary coil (yellow and black pair) of the transformer as the AC signal source. The black wire is the ground terminal.
- Connect to 110 V main supply
- Connect the output signal from the transformer (one secondary coil, yellow-black wire pair) into the oscilloscope channel 1
- Measure the signal amplitude
- Capture the signal
- Disconnect 110 V main supply
- Connect output signal from the circuit into the oscilloscope channel 1
- Connect to 110 V main supply
- Measure the output amplitude (output voltage)
- Capture the output signal
- Measure forward-bias voltage drop of the diode using the oscilloscope.
- Disconnect 110 V main supply

Power-supply filtering

- **Important:** Set the oscilloscope channels to "DC" mode
- Disconnect 110 V from the full-wave rectification circuit
- Connect a 22 μF or 15 μF capacitor across the output as shown in the Figure 3 **Important:** - Observe the polarity and connect positive terminal of the capacitor to positive terminal of the output.
- Connect 1 or 5 KΩ resistor as the load of the circuit.
- Connect output signal from the circuit into the oscilloscope channel 1
- Connect to 110 V main supply
- Measure the maximum output voltage (amplitude of the output signal)
- Measure the "ripple voltage", ΔV as shown in the Figure 3 (**You may use "AC" mode of the oscilloscope to calculate the ripple voltage easily.**)
- Capture output signal
- Calculate "ripple voltage", ΔV. Use the correct maximum current in your circuit for this calculation. (Hint: Using output voltage and load resistant to calculate the maximum current)
- Repeat steps through for 470 μF, 1000 μF and 2200 μF capacitors across the output

Dual-polarity (split) Power-supply

- Build the full-wave rectifier using both secondary coils of the center-tapped transformer as shown in the Figure 4
- Connect the two yellow cables to the full-wave rectifier. The black wire is the ground terminal and the common wire for positive and negative output.
- Use two 1000 μF capacitors
- **Important:** Set the oscilloscope channels to "DC" mode
- Connect output signal to the oscilloscope channels 1
- Connect to 110 V main supply
- Capture output signal

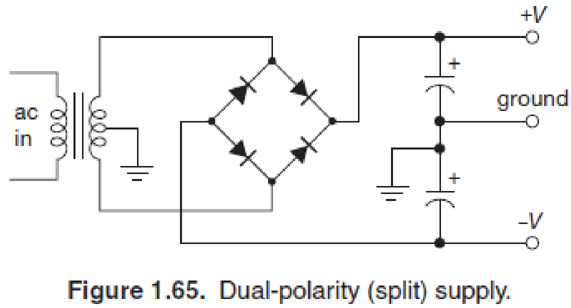


Figure 4: Dual-polarity (split) supply..

Additional Lab Questions

You will find useful to complete the lab questions before starting the lab.

1. Calculate the maximum current in the full-wave rectification circuit (Figure 2)?

2. For power supply filtering, an electrolytic capacitor was used and such capacitors are polarized. Discuss why electrolytic capacitor are polarized?

References

[1] Horowitz and Hill. *Art of Electronics*. Cambridge University Press, 2015.