

Lab 1 – Fun with Diodes (week of April 6th)

GOAL

The overall goal of this lab is to gain some experience building and simulating some useful diode circuits.

OBJECTIVES

To build, test, simulate, and understand the following circuits:

- 1) Half-wave rectifier with smoothing capacitor
- 2) Voltage limiter

GENERAL GUIDELINES

- 1) Each student must build, test, and demo all circuits.
- 2) During the lab session, students may need to share test stations.
- 3) Students are allowed (even encouraged) to help each other. Of course, Professor Hedrick will be around to provide assistance as well. Use neat wiring for your circuits! A messy circuit will cost you 10 pts from your lab demo grade.
- 4) Do not worry if you need lots of help during the lab. Just make sure you know your stuff for the exams. **In addition to the written exams, there will be two laboratory exams where each student is tested on basic skills in circuit construction and simulation.**
- 5) Ask questions! The more questions you ask, the more you learn (assuming Professor Hedrick can provide adequate answers ☺).
- 6) Build your circuits with neat wiring! Messy circuits will result in a 10 pt deduction from your lab demo grade. Neat means: correct wire colors, using ground and power busses, and a minimum of excess and crossed wires and components.
- 7) Please keep your lab kit and work area organized.

PARTS AND MATERIALS

- Lab kit (breadboard, wire stripper, wire)
- Digital oscilloscope and test probe
- Arbitrary waveform generator and coaxial cable (with alligator clips)
- Diode: 1N4002 (1)
- Resistors: 100 ohm (brown/black/brown) (1)
10 kohm (brown/black/orange) (1)
- Capacitors: 1 uF electrolytic (1)
100 uF electrolytic (1)
- LEDs: Green (1)
Red (1)

PART 1: HALF-WAVE RECTIFIER

- Step 1a: build the circuit in Figure
 - A messy circuit will cost you 10 pts from your lab demo grade.
- Step 1b: Input a sine wave (10 V_{pp}, 60 Hz) to the rectifier circuit.
 - Set the Agilent waveform generator to “High Z” output.
 - First, press “Utility”
 - Then “Output”
 - Then “High Z”
 - Finally, press “Done”.
 - Set the amplitude to 10 V_{pp} and frequency to 60 Hz.
 - Connect the output of waveform generator to the circuit input using the coaxial cable with alligator clips.
 - Press the “Output” button on the waveform generator to turn on the output.

NOTE: Remember that we discussed what this means in class: “High Z” means the load is expected to be high impedance (as opposed to 50 Ω, which is pretty low). Otherwise, the generator will output TWICE the voltage that you want (very annoying for this course).

- Step 1c: Measure a few cycles of the rectified voltage. You can ask Professor Hedrick for assistance if you are unable to configure each of the settings below. Your scope trace should similar to your PreLab1 (Circuit 1) simulation!
 - Press the “Default” button on the scope. This resets the scope.
 - Use CH1 of the scope to measure a few cycles of the rectified voltage.
 - **DO NOT PRESS AUTOSCALE!**
 - Professor Hedrick will deduct 300 pts from your lab grade if he catches you pressing “autoscale”.
 - CH1 voltage scale = 1 V/div
 - CH1 zero position = -2.0 V
 - Horizontal time scale = 5 ms/div
 - Trigger Level = 3 V
 - Make sure you scope probe is set to 10X, otherwise your measured voltages will be off by a factor of 10!
 - Measure the peak voltage using “Measure >> Vmax” on the scope and record this value.
 - Use the “swave” command in MATLAB to capture a scope trace.
 - Save this scope snapshot (e.g. jpg or emf file) for your lab report.

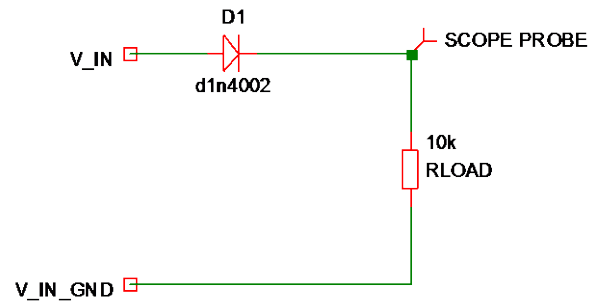


Fig. 1: Half-wave rectifier circuit.

PART 2: HALF-WAVE RECTIFIER WITH SMOOTHING CAPACITOR

- Step 2a: Fig. 2 shows the circuit for testing.
 - Place the 1 uF electrolytic capacitor in parallel with the 10 k Ω resistor.
 - Remember that electrolytic capacitors must be properly inserted into the circuit!
 - Apply the 10V_{PP}, 60 Hz sine wave to the input.

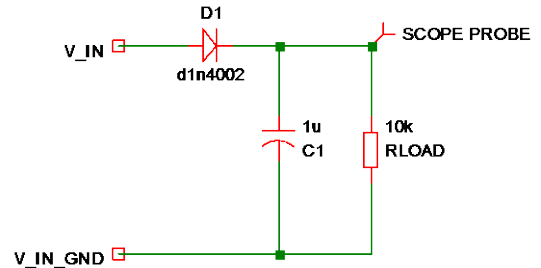


Fig. 2: Half-wave rectifier with 1 uF smoothing capacitor.

- Step 2b: Measure the load voltage with the scope. Your scope trace should like the PreLab1(Circuit2) simulation!
 - You should be able to use the same scope settings as Step 1c.
 - Measure the peak voltage using “Measure >> Vmax” on the scope and record this value.
 - Measure the voltage ripple using “Measure >> VPP” on the scope and record this value.
 - Capture a scope trace in MATLAB and save this scope snapshot for your lab report.

- Step 2c: Fig. 3 shows the next circuit for testing.
 - We can reduce voltage ripple by replacing the 1 uF capacitor with a 100 uF capacitor.
 - Remember that electrolytic capacitors must be properly inserted into the circuit!

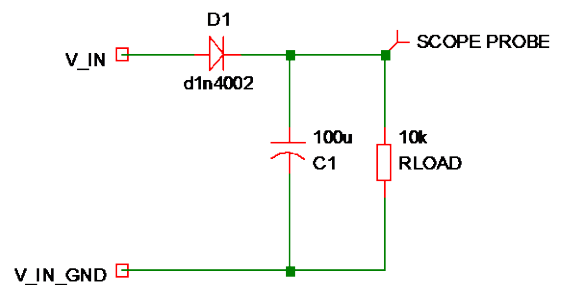


Fig. 3: Smoothing capacitor is now 100 uF.

- Step 2d: Measure the load voltage with the oscilloscope.
 - You should find that the scope trace looks pretty flat, but tends to flicker. This is because the scope trigger is not reliable, since the signal is so flat.
 - Measure the peak voltage on the scope and record this value.
 - In order to get a nice view of the voltage ripple, you will need to make several changes to the scope:
 - CH1 coupling = AC (go to “1” >> COUPLING >> AC)
 - CH1 voltage scale = 20 mV/div
 - CH1 zero position = 0 V
 - Trigger HF Reject = ON (go to TRIG MENU >> SET UP >> HF REJECT)
 - Trigger level = 20 mV
 - Your scope trace should look like your PreLab1(circuit3) simulation waveform.
 - Measure the voltage ripple and record this value.
 - Capture a scope trace in MATLAB and save this scope snapshot for your lab report.

PART 3: VOLTAGE LIMITER

The “simple AC voltage tester” is really a voltage limiter using LEDs instead of diodes. Both LEDs should light up! Note that an actual AC voltage tester is usually capacitively coupled (a topic we will cover soon ...).

- Step 3a: Fig. 4 shows the voltage limiter circuit.

- Remember the (-) end of the LED is the “flat end” of the LED package.
- Remember that the green and red LEDs are pointing in opposite directions!
- Apply a $10V_{PP}$, 10 Hz sine wave to the input.
- Both LEDs should light up!

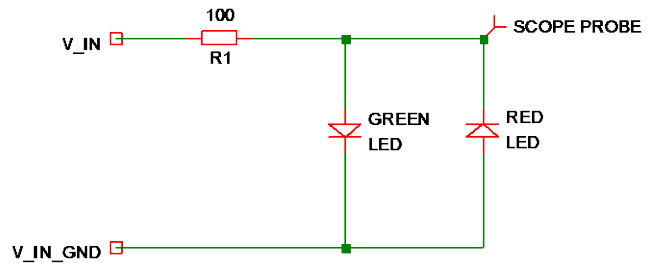


Fig. 4: Voltage limiter circuit using green and red LEDs.

- Step 3b: Measure the load voltage with the oscilloscope.

- Make the following changes to the scope settings:
 - CH1 coupling = DC
 - CH1 voltage scale = 1V/div
 - CH1 zero position = 0 V
 - Horizontal time scale = 20 ms/div
 - Trigger Level = 0 V
- Your scope trace should look like your PreLab1(circuit 4) simulation. The signal is clipped at approximately +/- 2V. The clipping is not abrupt (the “corners” are pretty rounded).
- Measure the maximum and negative voltages and record these values.
- Capture a scope trace in MATLAB and save this scope snapshot for your lab report.

- Step 3c: Reduce the function generator sine wave voltage to $1V_{PP}$.

- Your scope trace should now look like an undistorted $1V_{PP}$ sine wave.
- You do NOT need to record a scope trace.
- Why are the scope traces in Step3b and 3c different? You must explain this difference in your lab report.

PART 4: CIRCUIT DEMOS (30 PTS OF TOTAL LAB GRADE)

Professor Hedrick will reset the scope and ask you to show the following scope traces with the proper scope settings:

- Half-wave rectifier with 1 μF capacitor (15 pts of lab demo grade)
 - Input = 10 V_{PP} , 60 Hz sine wave
 - Scope probe measures load voltage
 - Scope settings:
 - CH1 voltage scale = 1 V/div
 - CH1 zero position = -2.0 V
 - Horizontal time scale = 5 ms/div
 - Trigger Level = 3 V
 - Measurements = V_{MAX} and V_{PP}

- Voltage limiter (15 pts of lab demo grade)
 - Input = 10 V_{PP} , 60 Hz sine wave
 - Scope probe measures load voltage
 - Scope settings:
 - CH1 voltage scale = 1 V/div
 - CH1 zero position = 0 V
 - Horizontal time scale = 5 ms/div
 - Trigger Level = 0.5 V
 - Measurements = V_{MAX} and V_{MIN}

NOTE: When you demo your circuits, Professor Hedrick will ask you to operate the scope WITHOUT USING THE AUTOSCALE BUTTON. **Professor Hedrick will deduct 300 pts from your lab grade if you press Autoscale!**

(End of Lab 1)

Spring 2015