CE 3111.103

Lab 2: Rectifier

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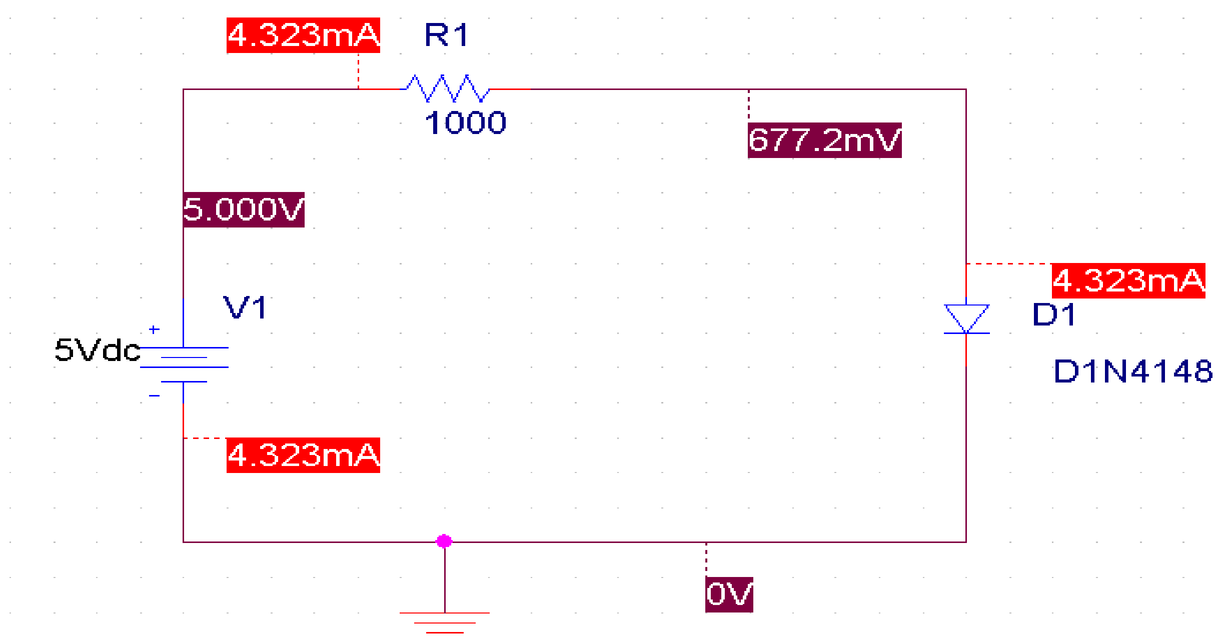
Objective

Familiarize with how diodes are used in limiting and rectifying circuits.

Experimental Results

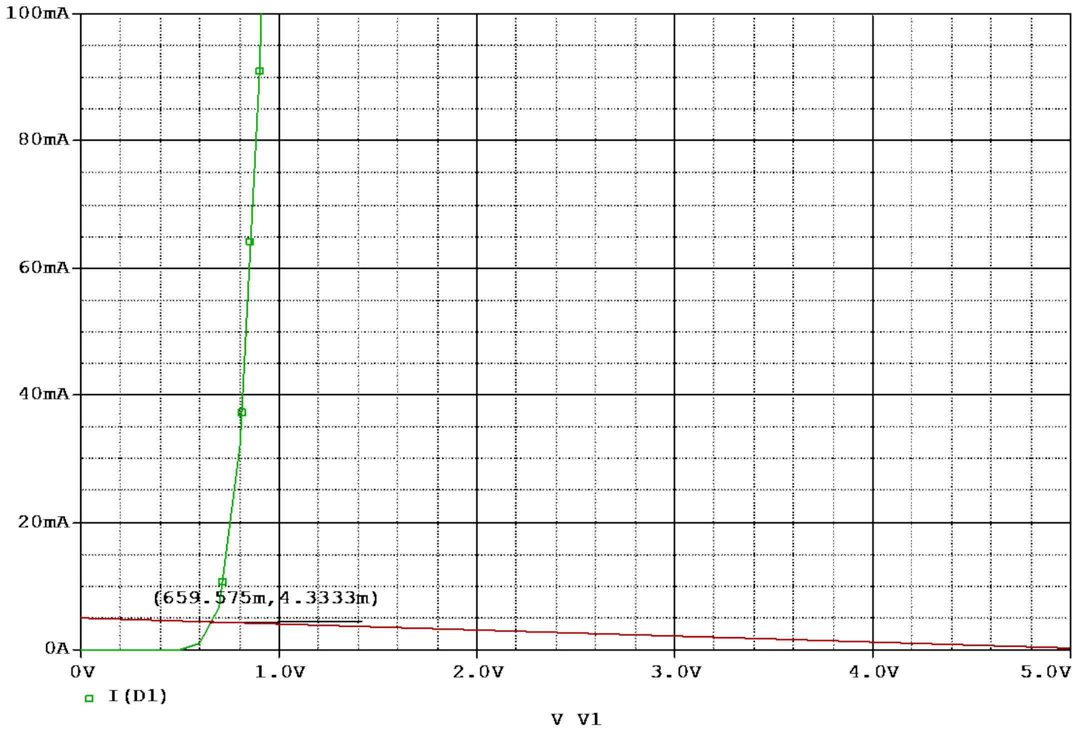
- Limiting circuit
  - Schematic:

  - Method 1:
    - $V_{R1} = 5 - 0.7 = 4.3V$
    - $\mathrm{R1} = \frac{4.3V}{4.3mA} = 1000\Omega$
  - Method 2:

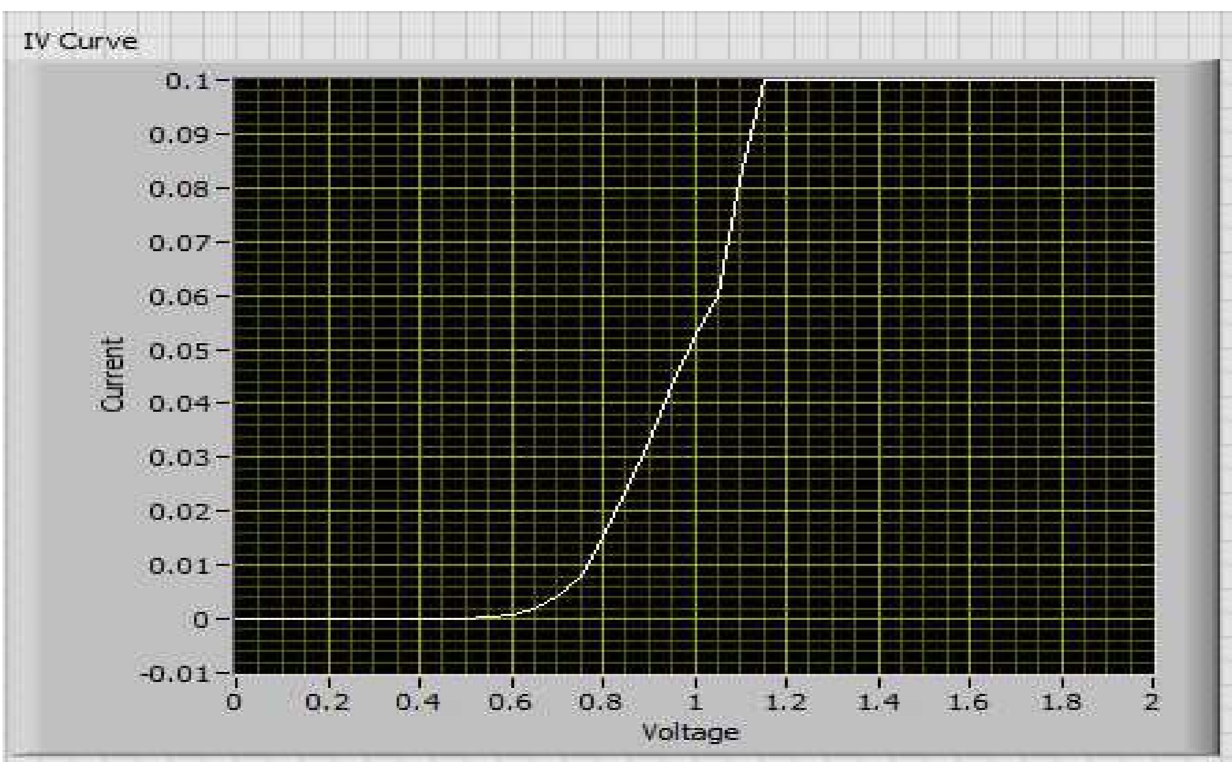


The results match, showing 1kΩ is necessary to output 4.3mA when the Vin is 5V.

  - I-V characteristic
    - Simulate

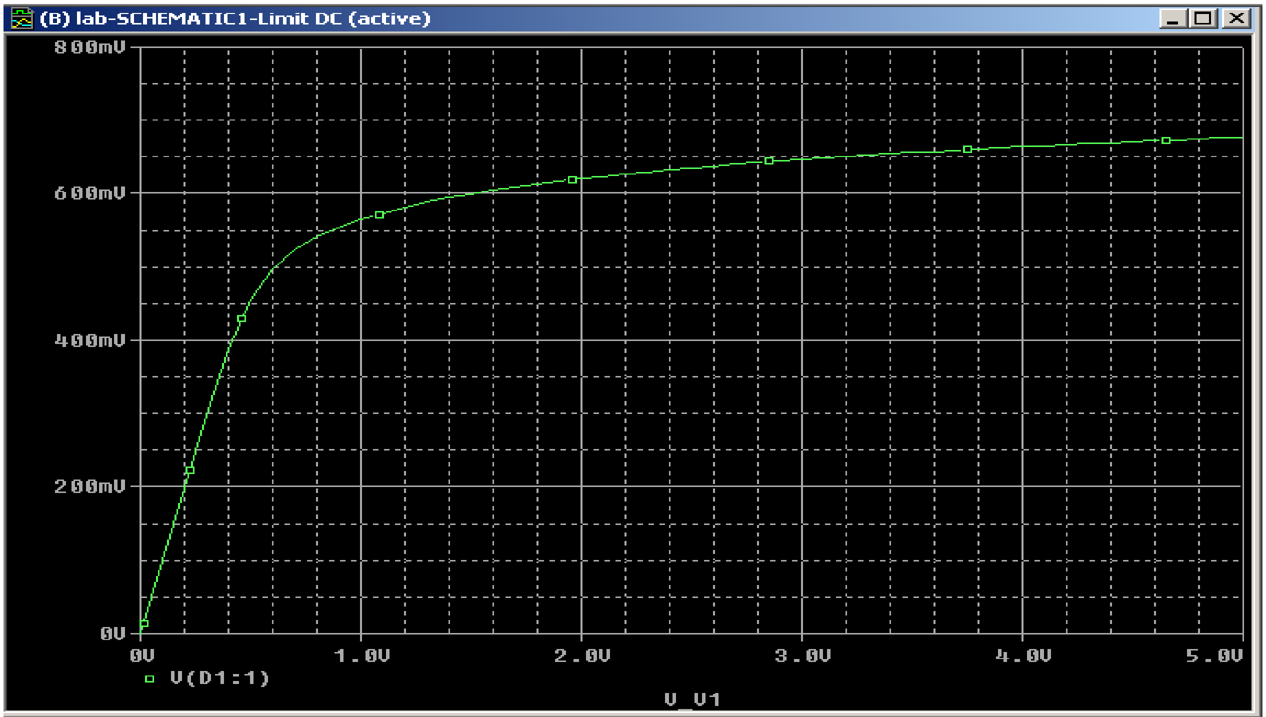


- In Lab:

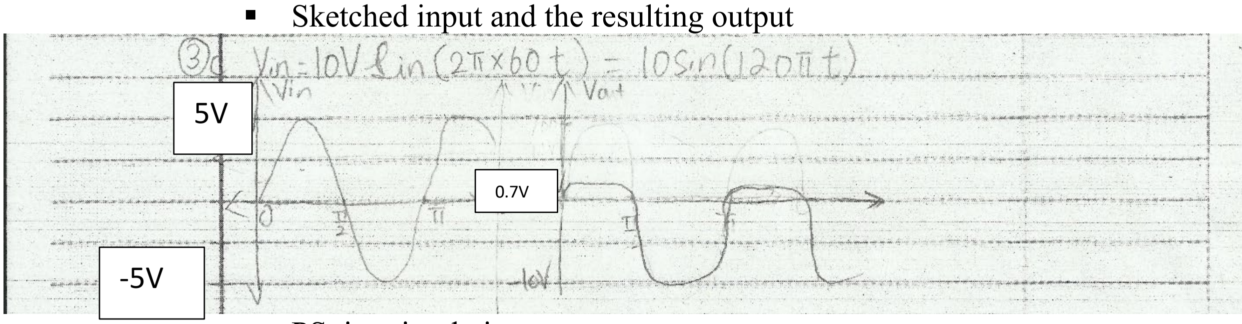


- Both graphs display the same characteristics for the diode. However, PSpice assumes the diode can take infinite amount of voltage while in reality, the diode current saturates.

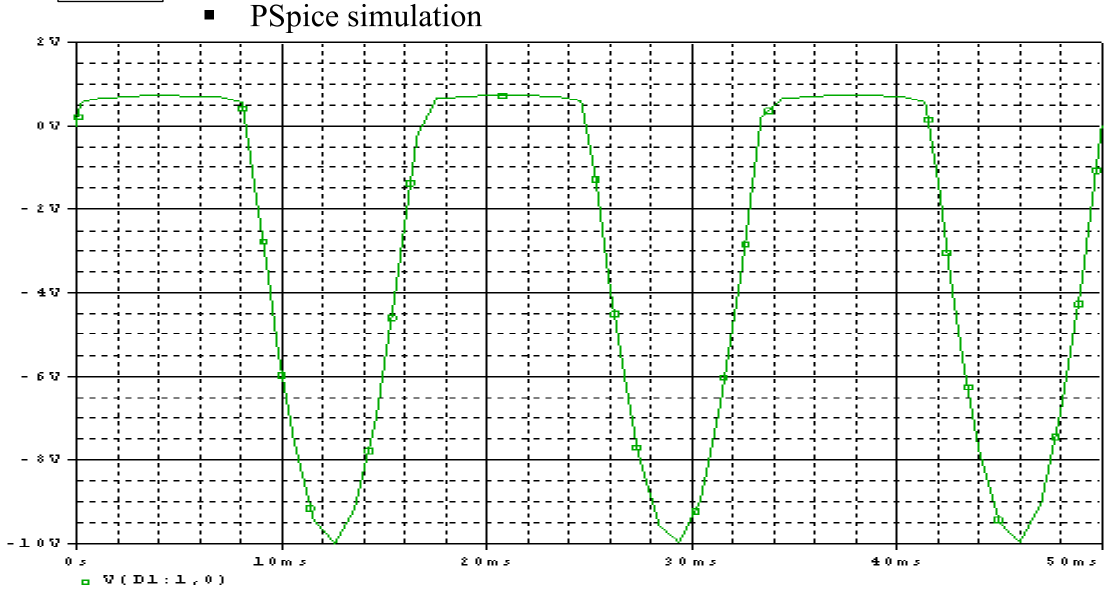
- Transfer function



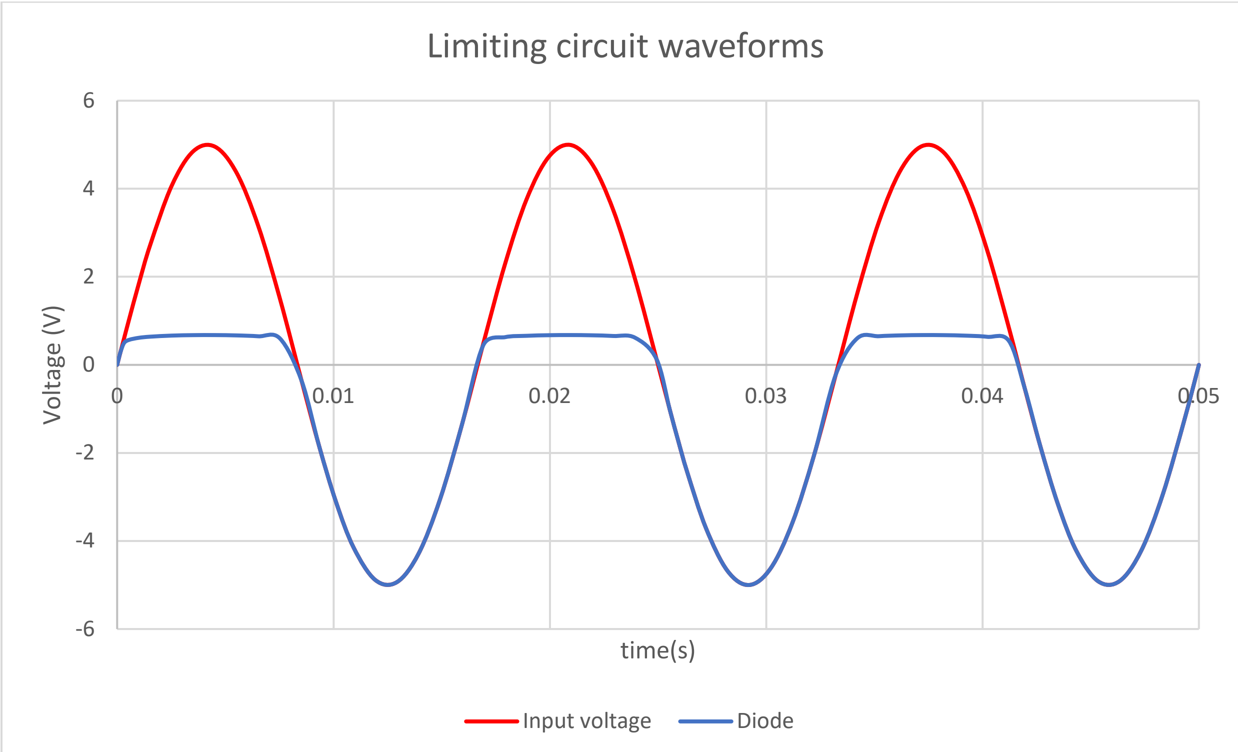
- 60Hz sine wave input
  - Sketched input and the resulting output



  - PSpice simulation

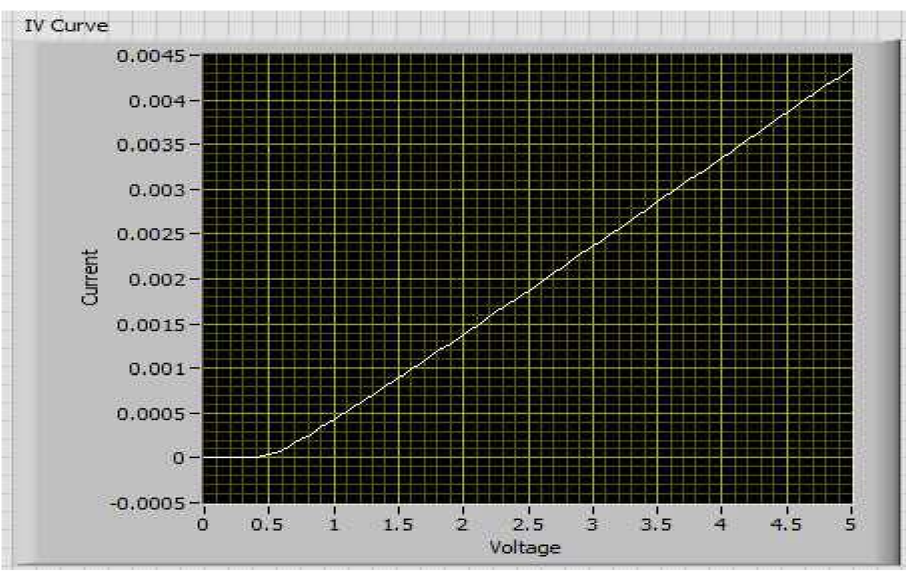


- Lab result

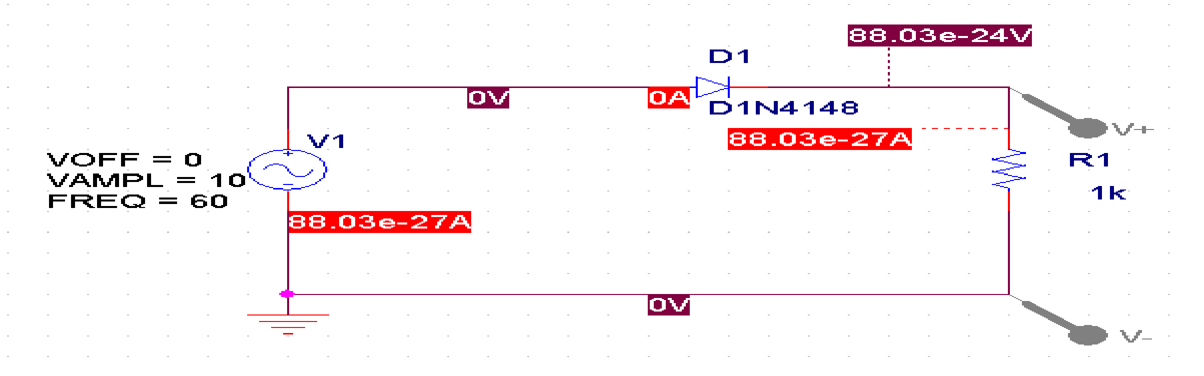


The voltage across diode shows no significant discrepancies across the expectation result, simulation result, and the lab result. The turn on voltage of diode in the lab has an insignificant difference possibly due to the operation temperature.

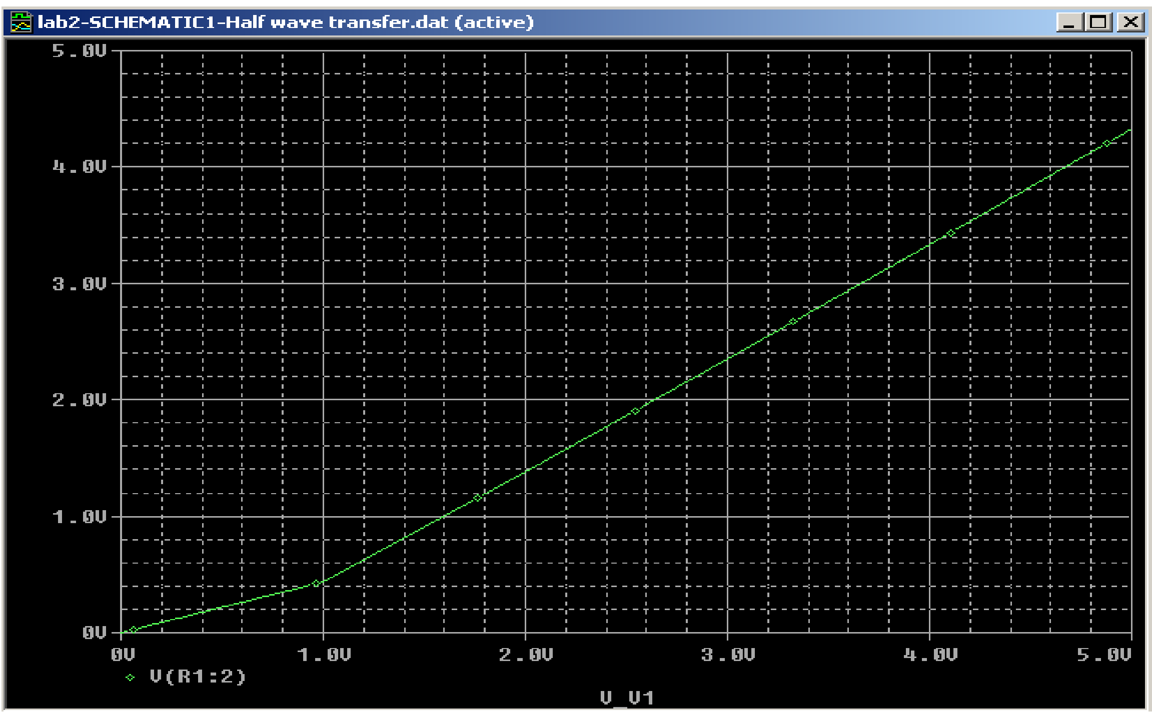
- DC Sweep



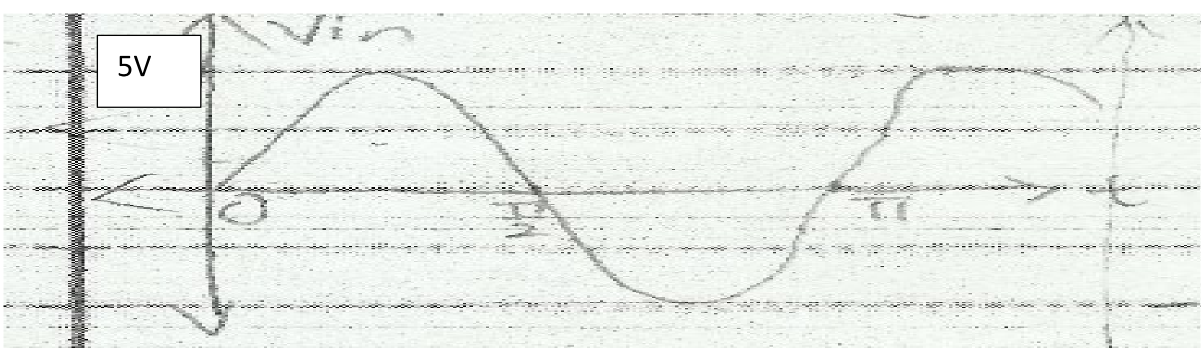
- Half-wave rectifier
  - Schematic

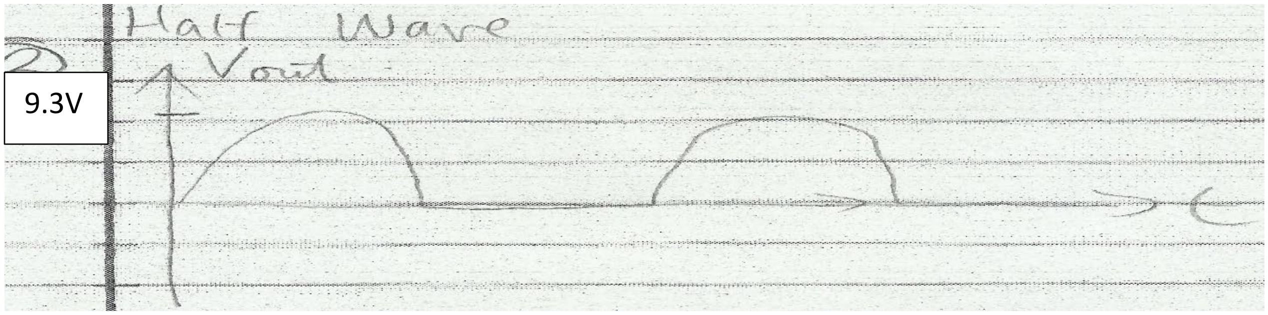


  - Transfer function

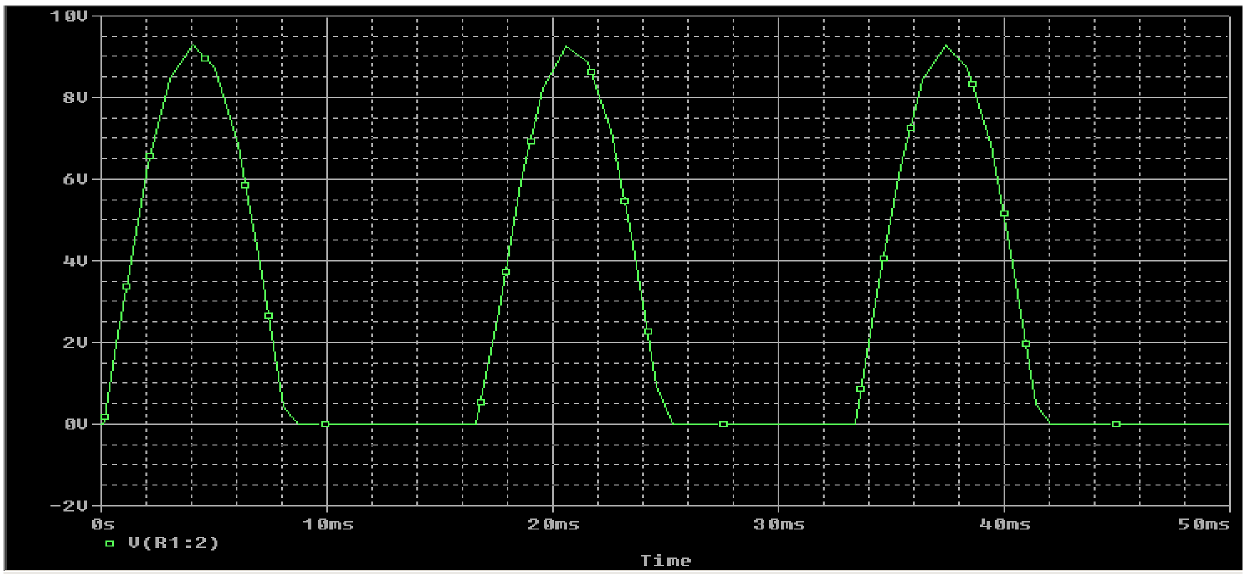


  - 60Hz input and output (sketched)

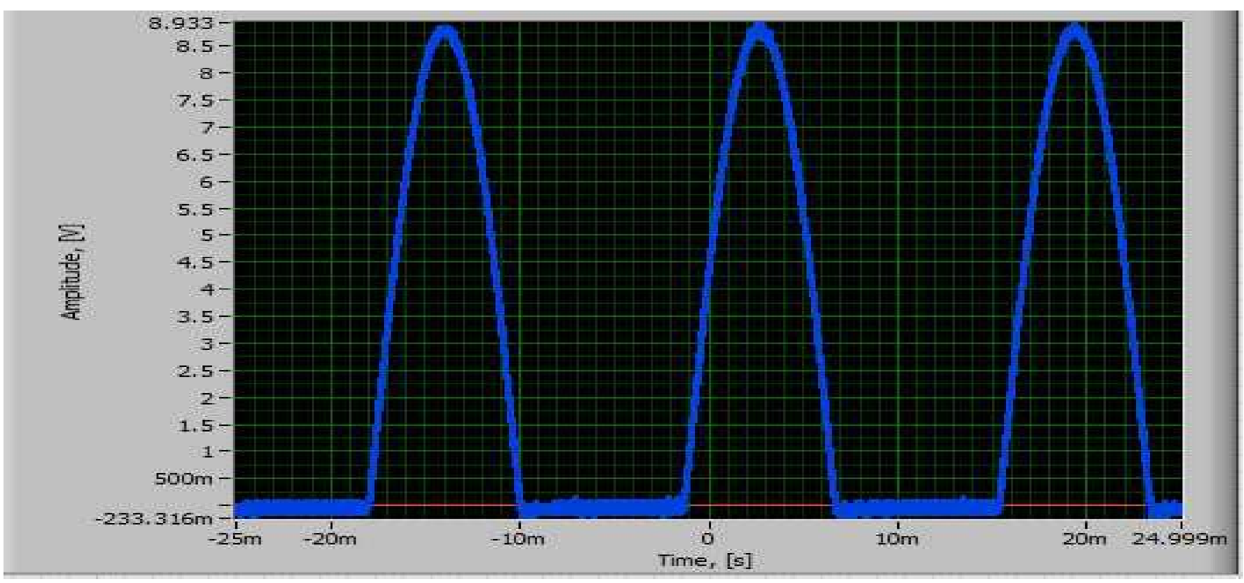




- 60Hz output
  - PSpice

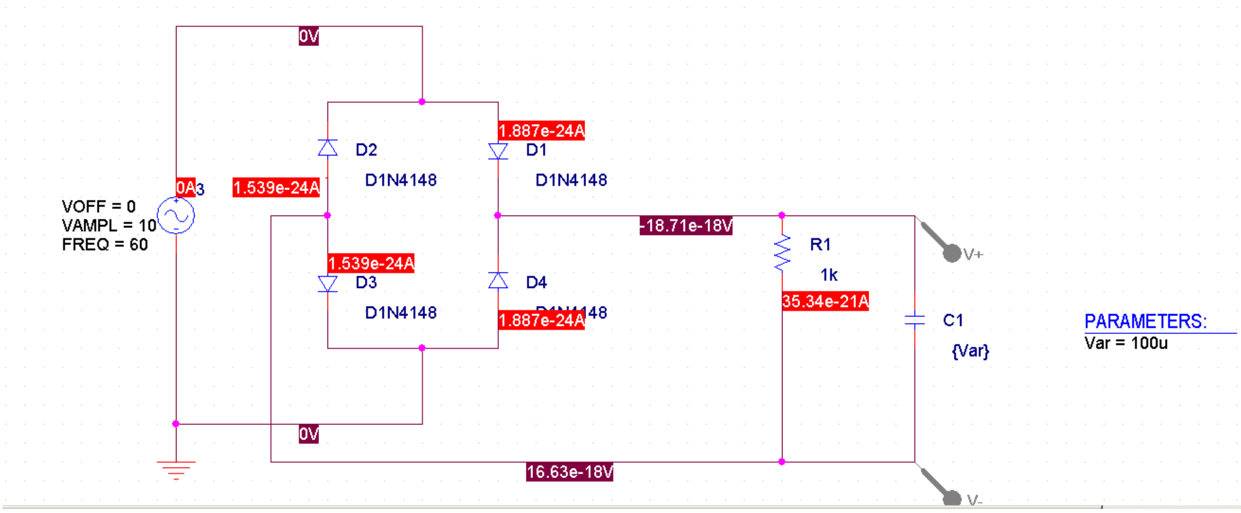


  - Lab

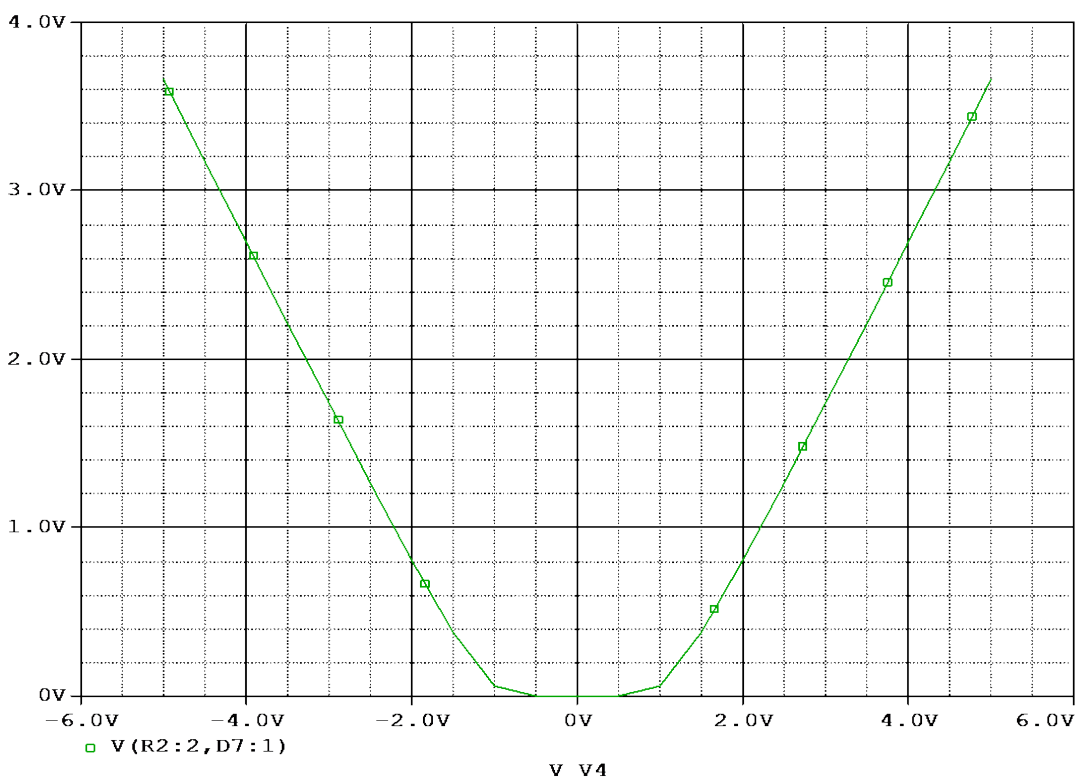


The results are similar to each other. The peak voltage is different from the experimental value due to the operational environment and the diode condition. The reversed biased voltage was assumed 0V in the simulation while in reality some reversed biased voltage remains.

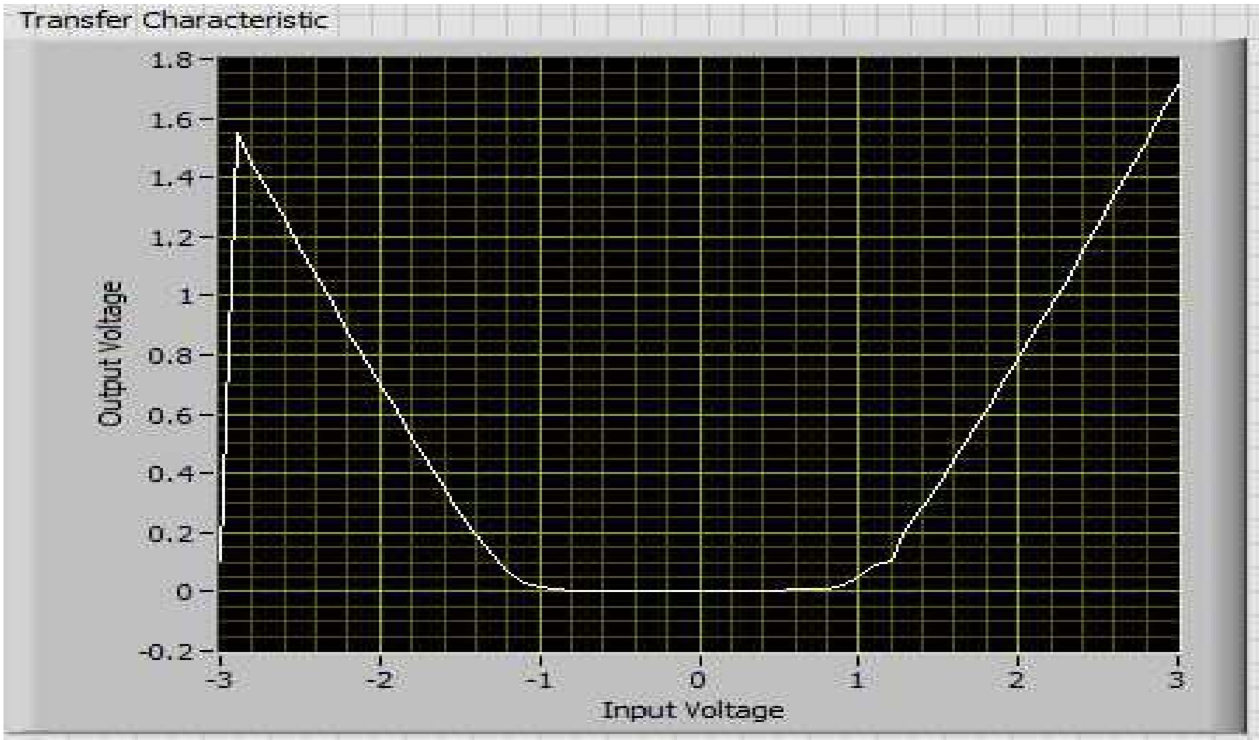
- Full wave rectifier
    - Circuit



    - Transfer function
        - PSpice

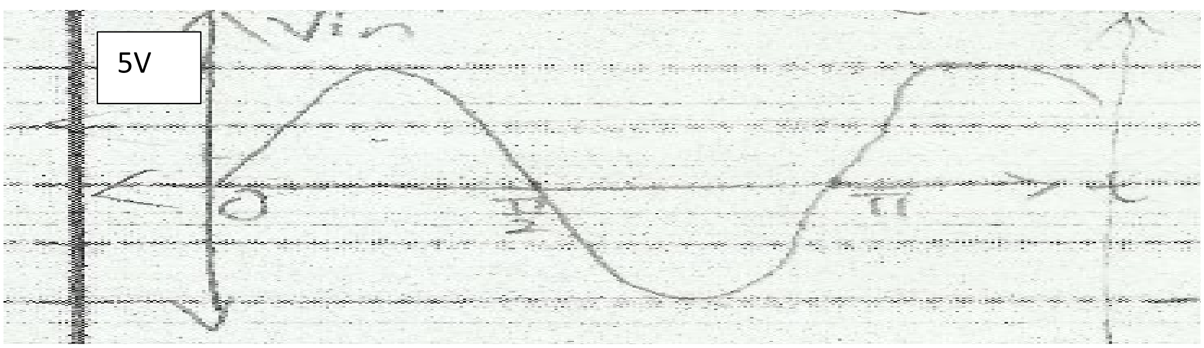


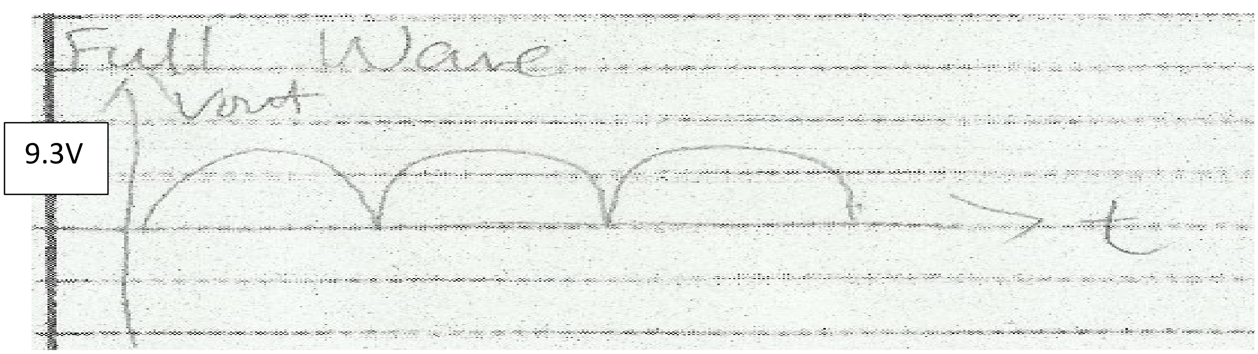
- Lab



The actual lab result shows the effect of breakdown due to the reversed biased diode

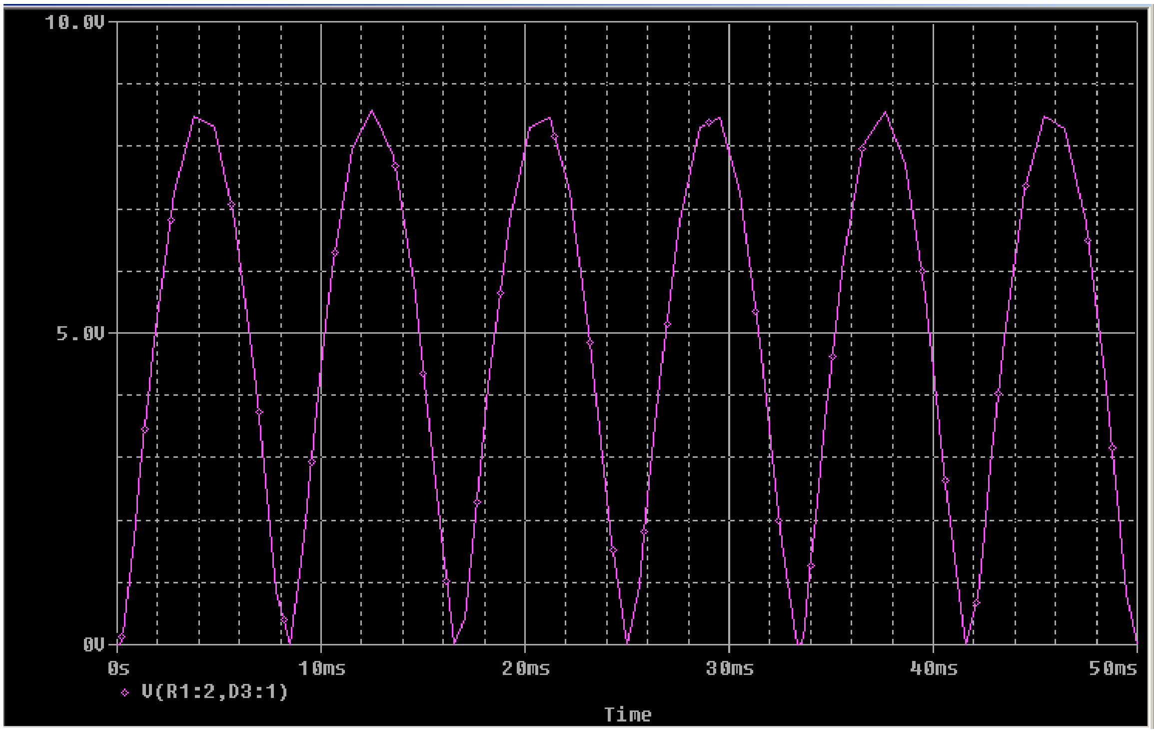
- 60Hz (sketch)



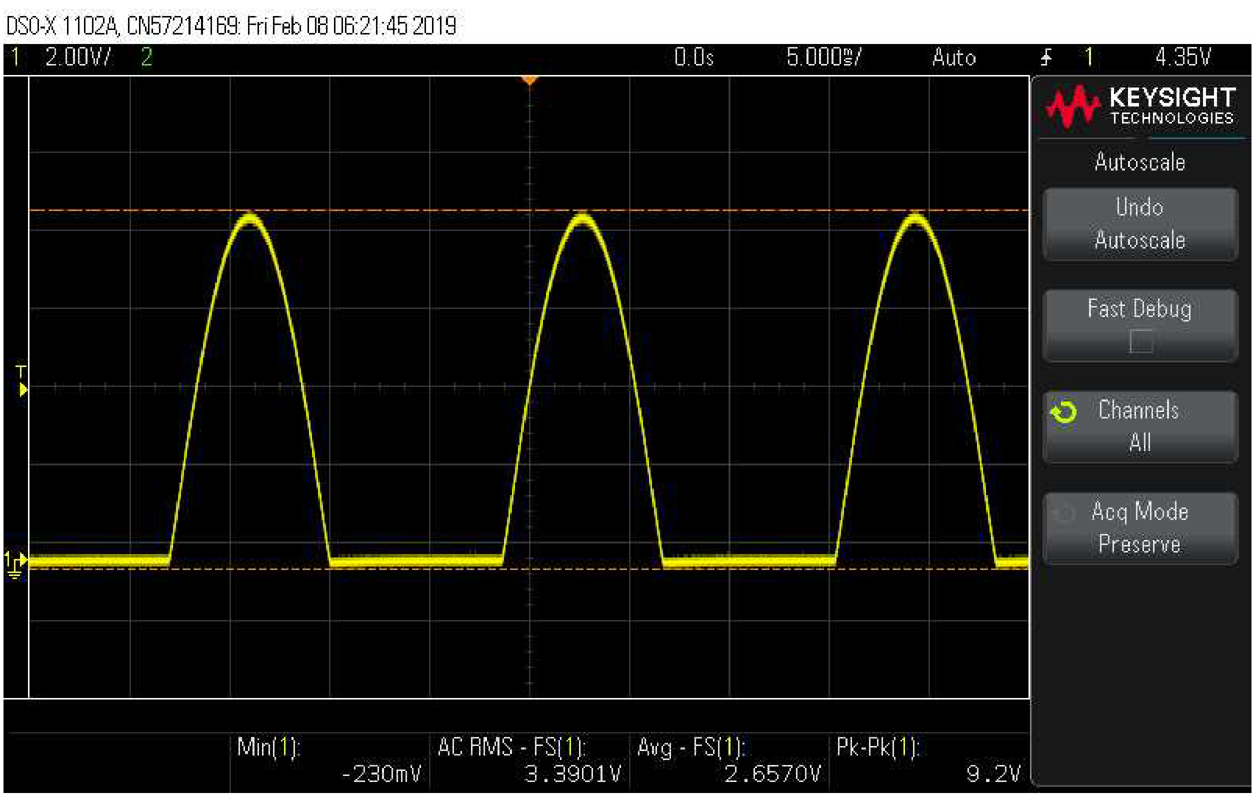


- 60Hz output

- PSpice

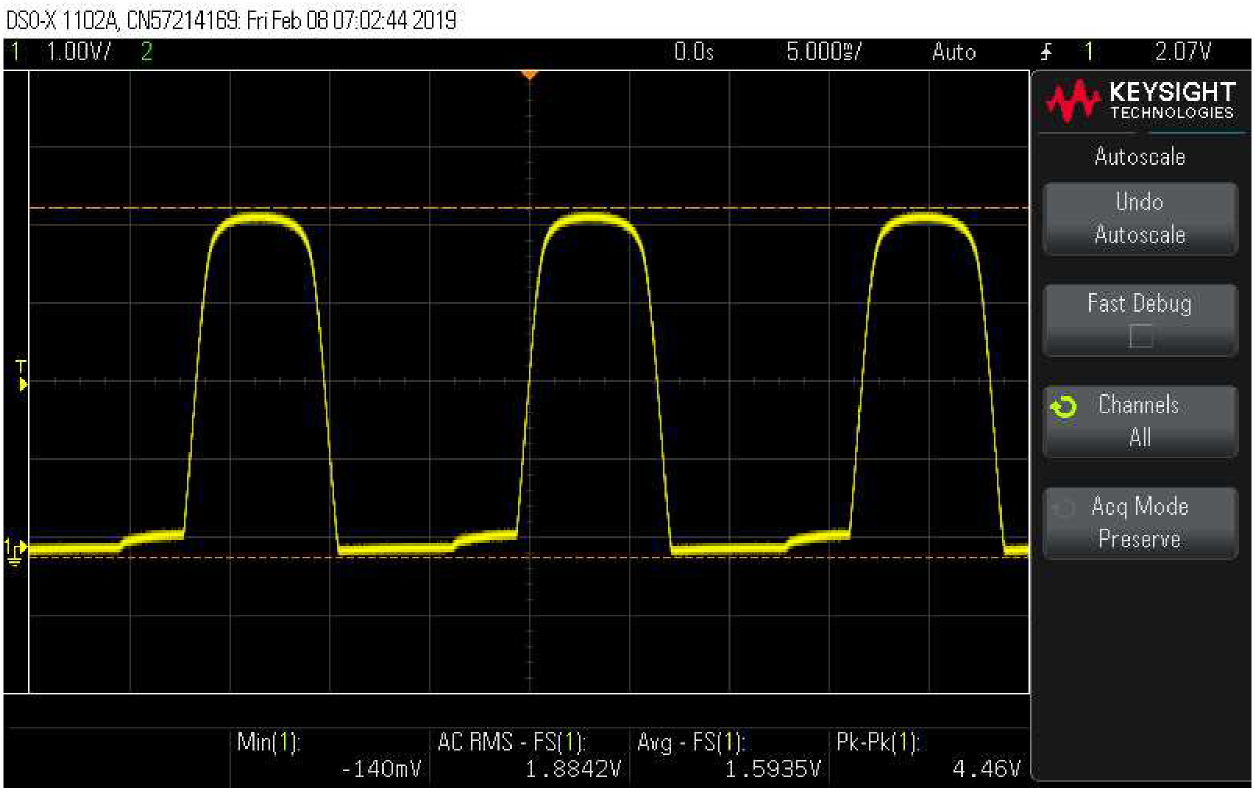


- Lab

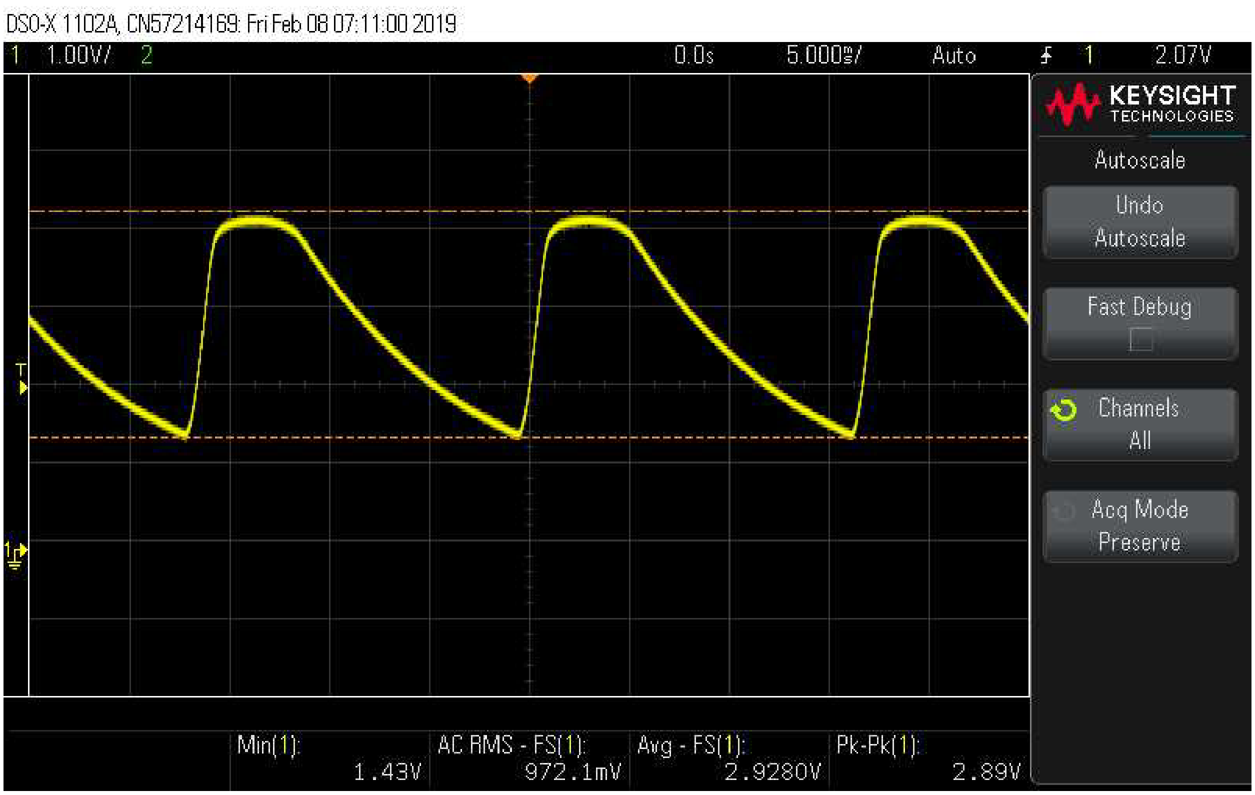


- Ripple

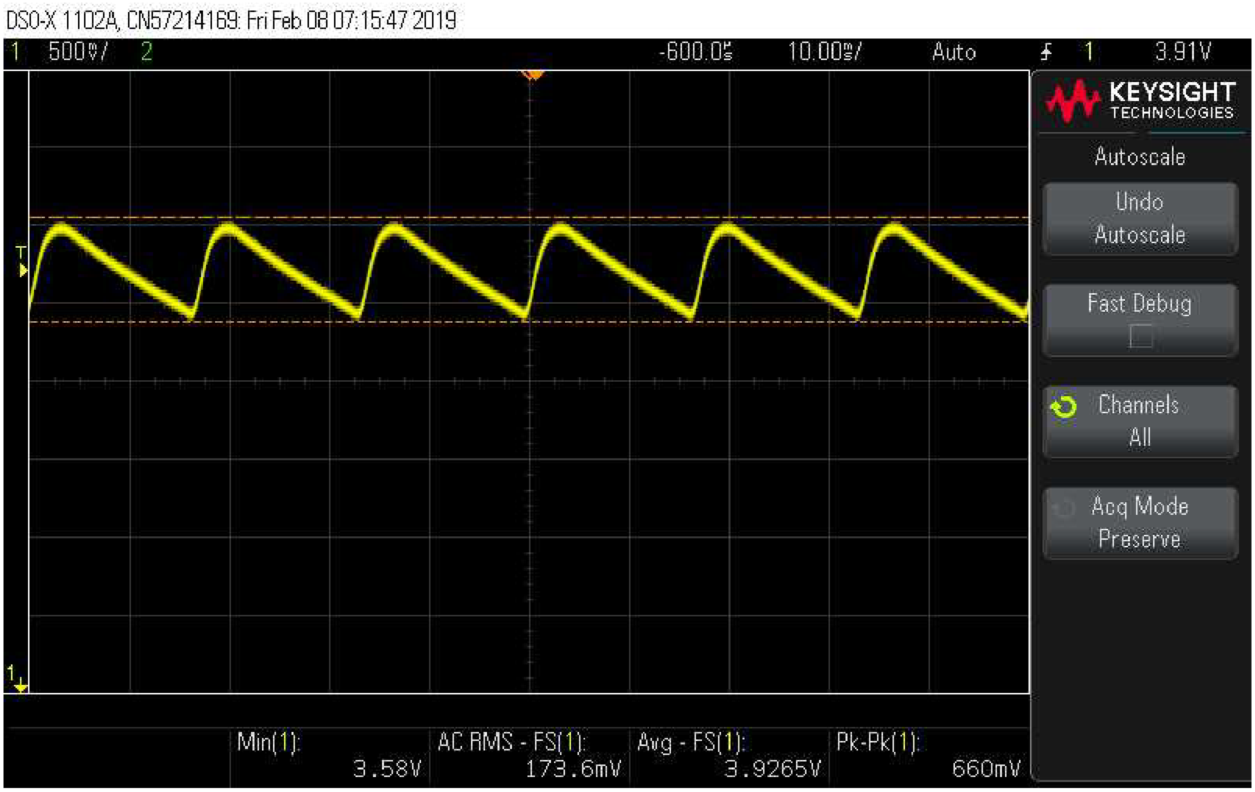
- 1μF Vpp=4.46V



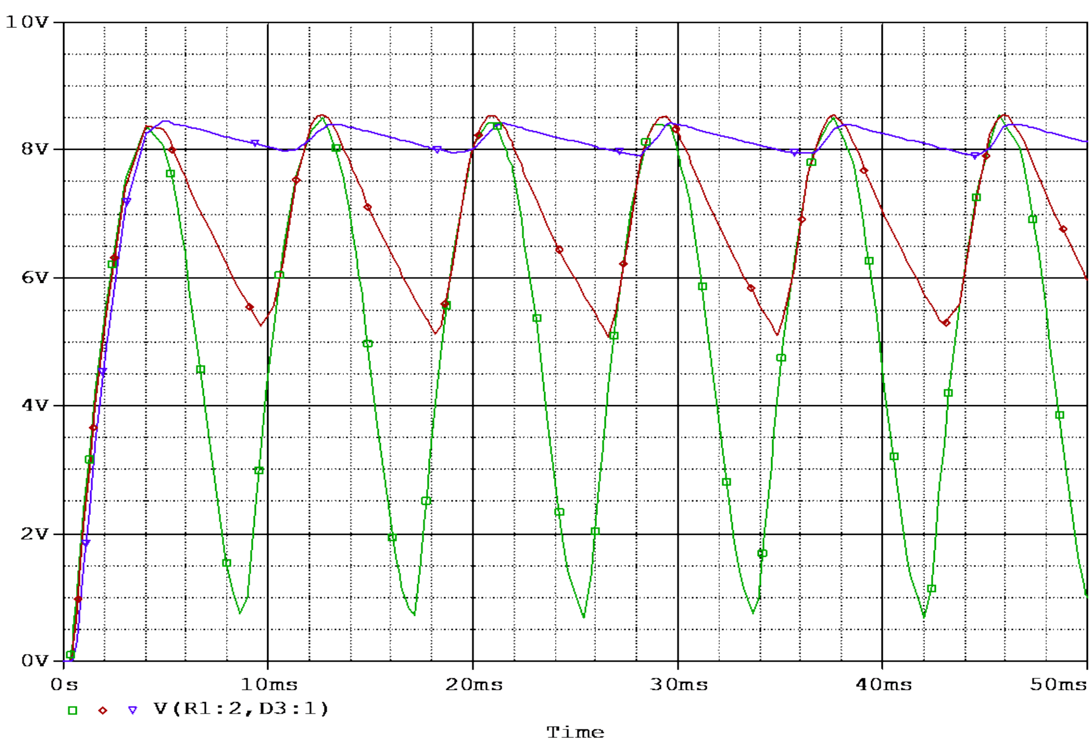
- 10μF Vpp=2.89V



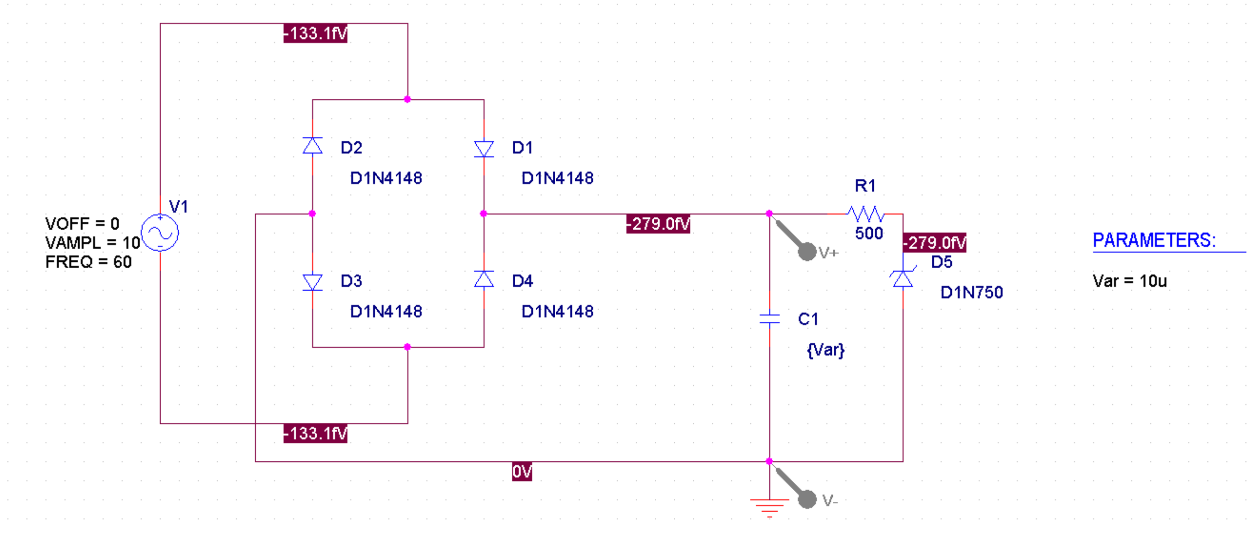
- 100µF Vpp=660mV



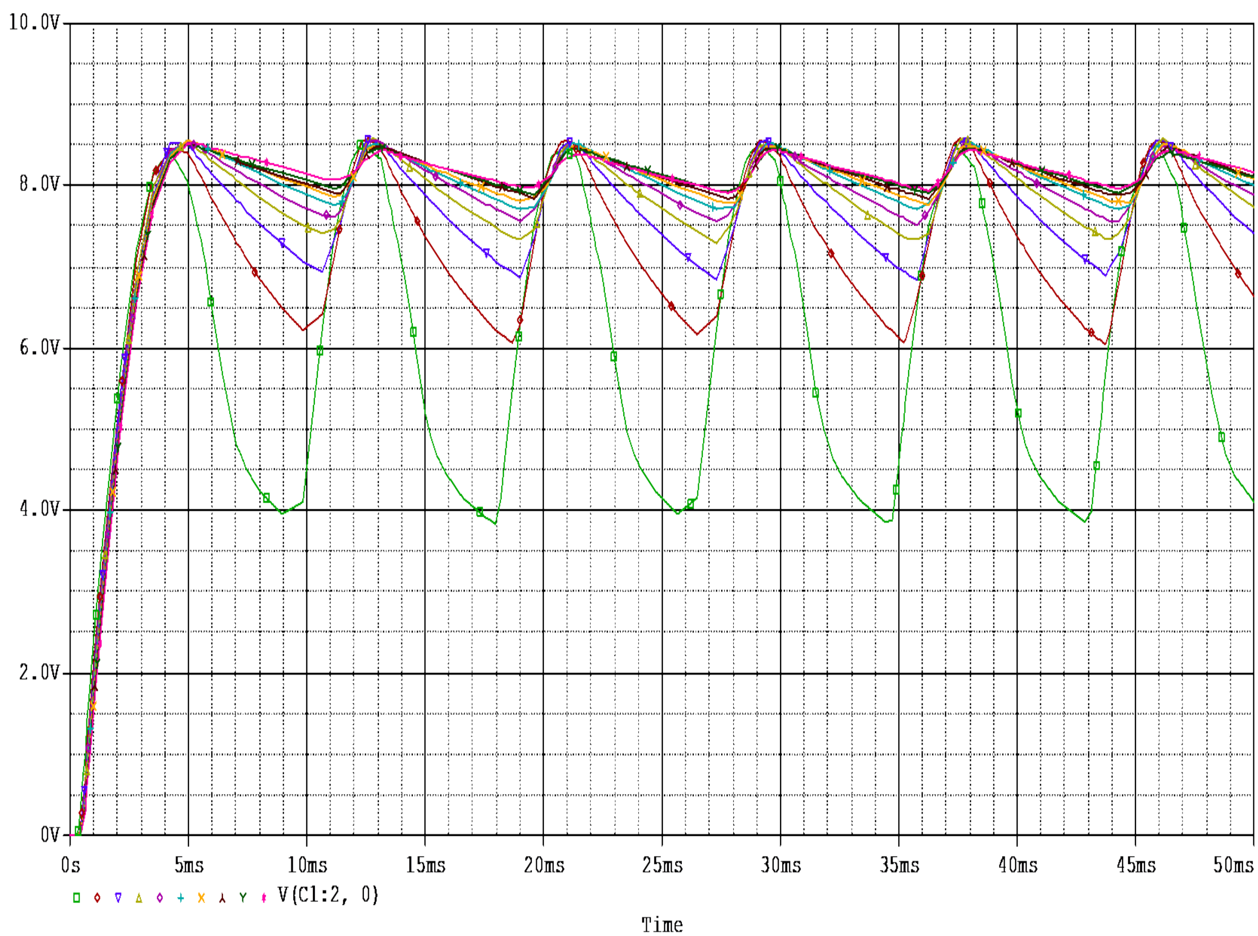
  - Capacitive parametric sweep



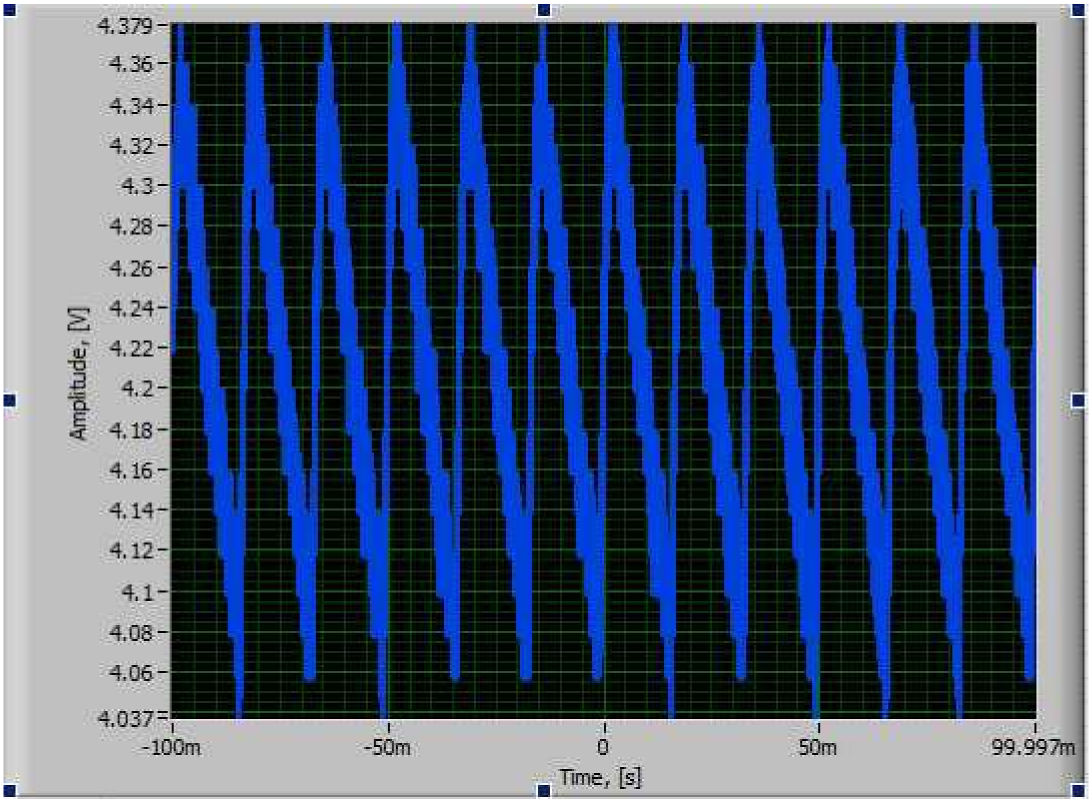
- Voltage regulated power supply
  - Circuit



  - Capacitive parametric sweep

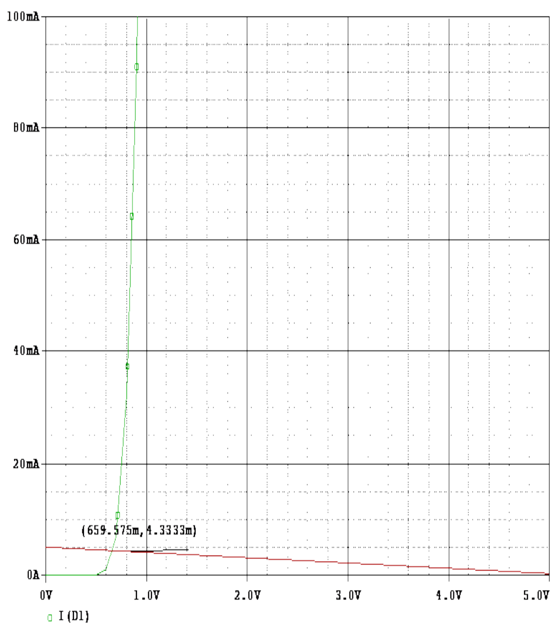


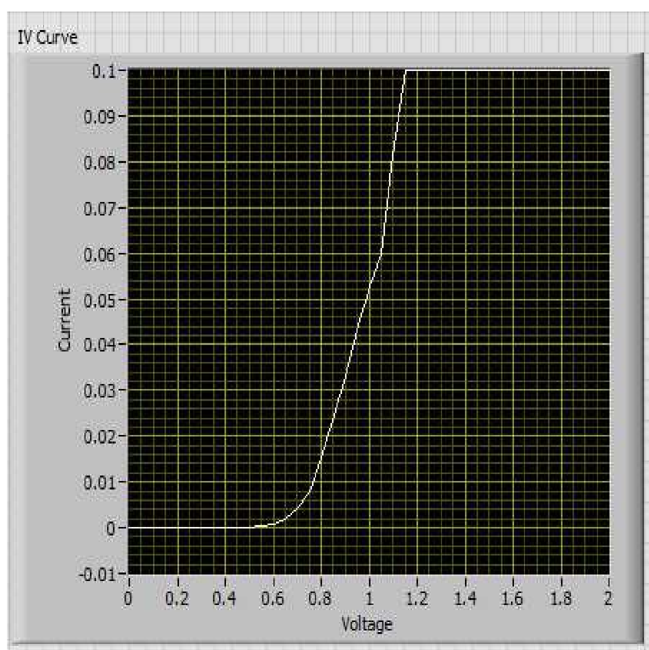
- Circuit output in Lab



Analysis Questions

1. Limiting circuits
    a.





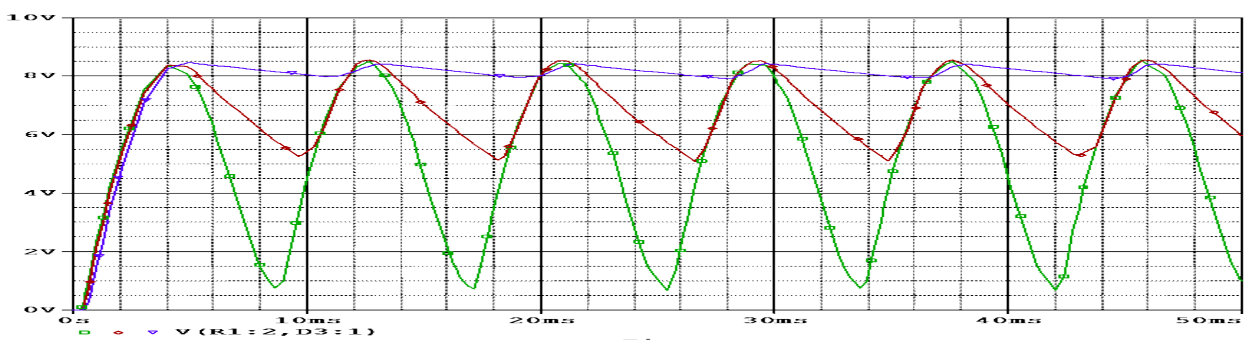
	Both graphs display the same characteristics for the diode. However, PSpice assumes the diode can take infinite amount of voltage while in reality, the diode current saturates.

b.

Experimented $V_{operational}$	V_f	Error
0.6596V	0.7V	-5.77%

c. After the turn-on voltage, the diode acts like a wire. The current through the wire grows linearly with the voltage.

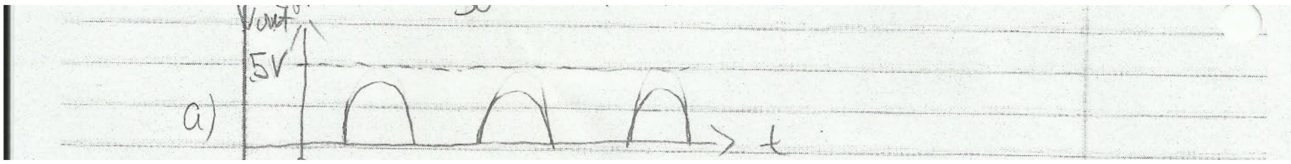
2. Half-wave rectifier
   a. The peak shifts up to 10V because the current through the circuit is limited. According to Ohm's Law, V=IR, when resistor does not change, and the current reduces, the voltage shall increase.
   b. Because under the reversed biased, there are few electrons able to pass through the terminal to stabilize the depletion region in diode, causing the early effect.
   c. Because the way we configure the circuit diverts the direction of electricity from up to down, and we choose to probe the voltage assuming the positive end at top and the negative end at the bottom.
3. Limiting circuit and the half wave rectifier
   a. It blocks all the incoming voltage
   b. The limiting circuit outputs 0.7V.When 0.7V is passed into the half wave rectifier, considering that Vf=0.7V, the resulting output = 0V.
4. Full-wave rectifier
   a. The results are very close to their correspondent



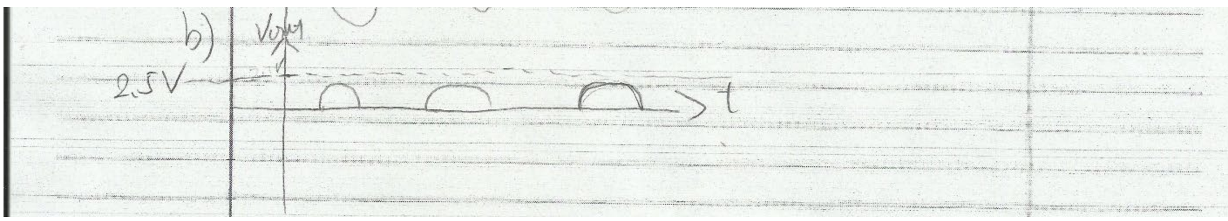
   b. To further smooth the difference of voltage drop, and eventually creating a smooth signal
   c. The higher the capacitance, the less variant the peak voltage is to be.
5. Voltage regulated power supply
   a. The Zener diode breakdown effect provides a even smaller peak voltage drop from each AC period.

Thought Questions

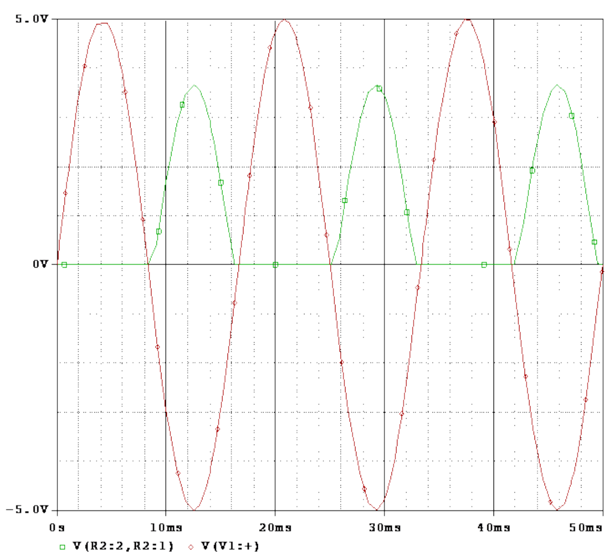
1.
   a. When Vin is negative, the V_{out} will invert Vin to positive with the reduction of the turn on voltage of the remaining diodes. When Vin is positive, V_{out} receives no output.

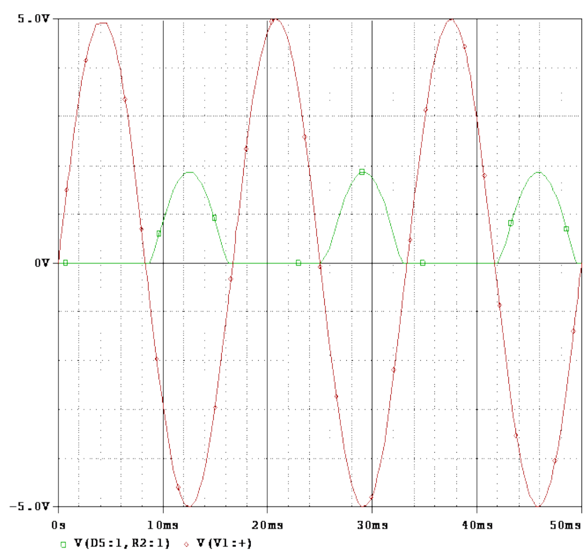


   b. Since the polarity of D1 is reversed, When Vin is positive, there is no route for Vin to reach the load resistor, resulting V_{out}=0V. When Vin is negative, D1 becomes a short when Vin is greater than 2V. Thus $V_{out} = 0.5Vin - V_{D,ON}$



2. (a) (b)





3. (b) may cause hazardous situation, since it is a direct short circuit when Vin is negative.
4. The capacitor with high capacitance under a high frequency circuit may not have time to charge or discharge. It will stack up the voltage overtime and cause a short circuit or a high-voltage circuit.

Conclusion

Experimental result cope closely with the simulation. Discrepancies rises where the assumption uses theoretical models whereas the reality posts more restrictions.