Lab 5

Diodes (Characteristics, Rectifiers, and Multiplier)

Introduction:

A diode is an electrical device that allows current to move through it in one direction with far greater ease than in the other. When placed in a simple battery-lamp circuit, the diode will either allow or prevent current through the lamp, depending on the polarity of the applied voltage.

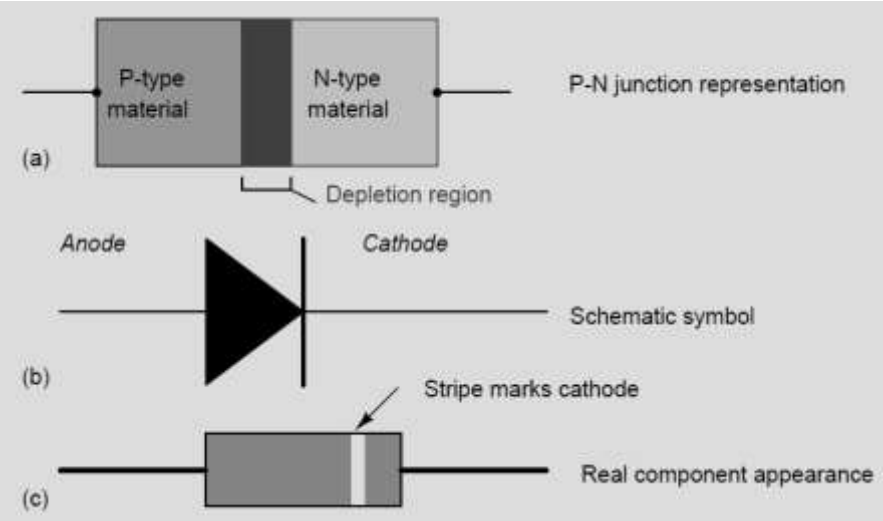


Figure 1: Diode representations: PN-junction model, schematic symbol, the physical part.

A- Diode characteristics:

If a reverse-biasing voltage is applied across the P-N junction, this depletion region expands, further resisting any current through it. Conversely, if a forward-biasing voltage is applied across the P-N junction, the depletion region collapses becoming thinner. The diode becomes less resistive to the current through it. In order for a sustained current to go through the diode; though, the depletion region must be fully collapsed by the applied voltage. This takes a certain minimum voltage to accomplish, v called the forward voltage as illustrated in Figure.3

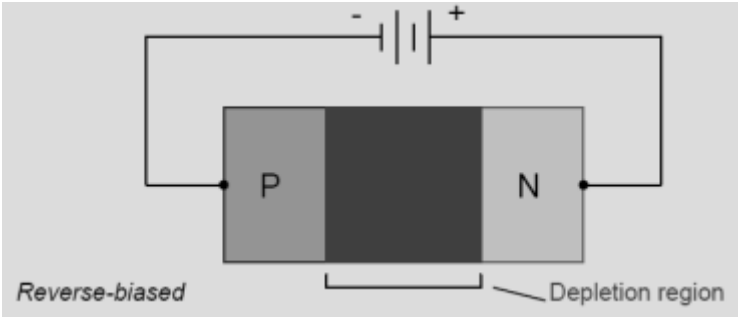


Figure 2: The depletion region expands with reverse bias.

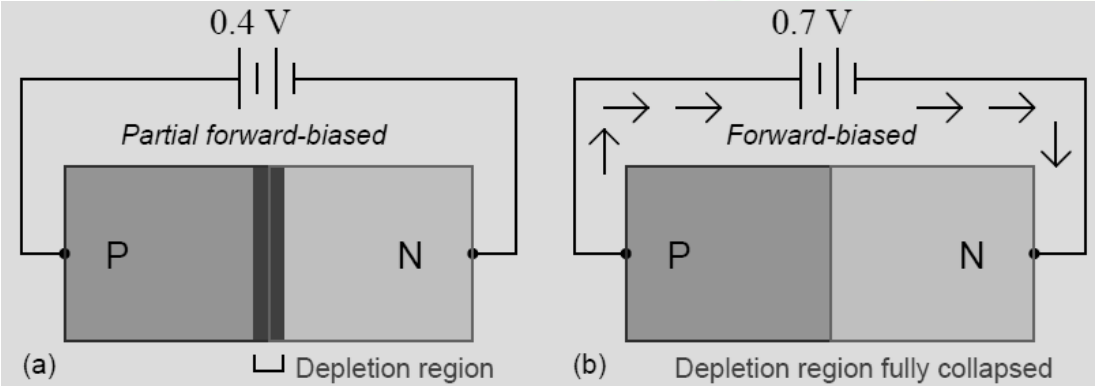


Figure.3: Increasing forward bias from (a) to (b) decreases depletion region thickness.

Actually, the forward voltage drop is more complex. An equation describes the exact current through a diode, given the voltage dropped across the junction, the temperature of the junction, and several physical constants. It is commonly known as the diode equation:

$$ID = Is\ (e^{qVDNKT} - 1)$$

ID: Diode current in amps
IS: Saturation current in amps (1 x 10-12)
e: Euler Constant (2.718281828)
q: charge of the electron (1.6 x 10-19 coloumbs)
VD: Voltage applied across diode in volts
N: "Nonideality" or "emission" coefficient (1-2)
K: Boltzmann's constant (1.38 x 10-23)
T: Junction temperature in Kelvins

The term kT/q describes the voltage produced within the P-N junction due to the action of temperature and is called the thermal voltage, or Vt of the junction. At room temperature, this is about 26 millivolts. Knowing this, and assuming a "nonideality" coefficient of 1, we may simplify the diode equation and re-write it as such:

$$ID = Is\ (e^{VD0.026} - 1)$$

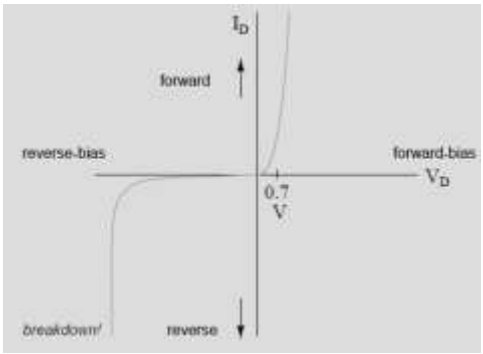


Figure 4: Diode curve: showing knee at 0.7 V forward bias, and reverse breakdown

I. Experiment

- Consider the circuit as Fig.5
- You are required to simulate the following circuit to determine I-V characteristics for the diode.

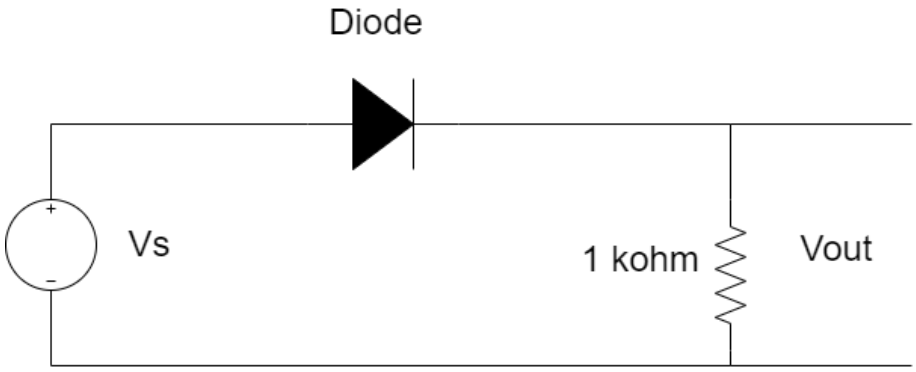
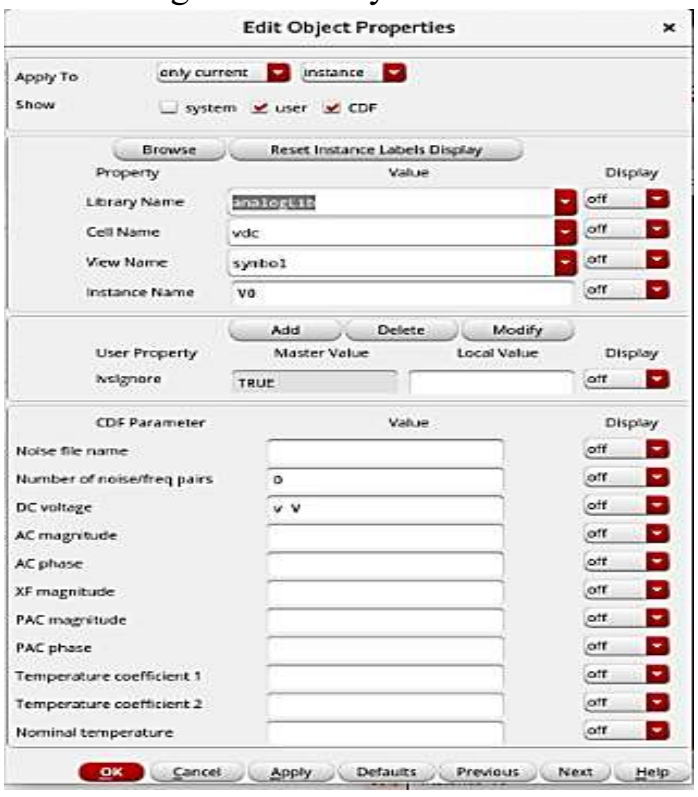


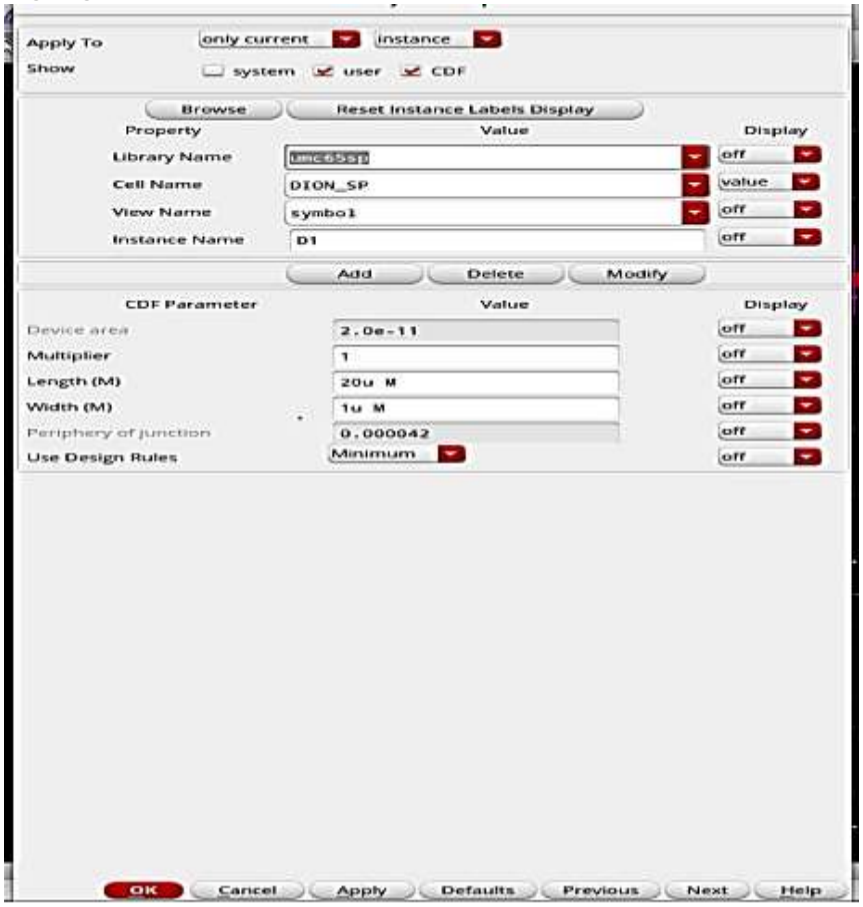
Figure 5: The setup of the characterization of the diode.

II. Simulation procedures:

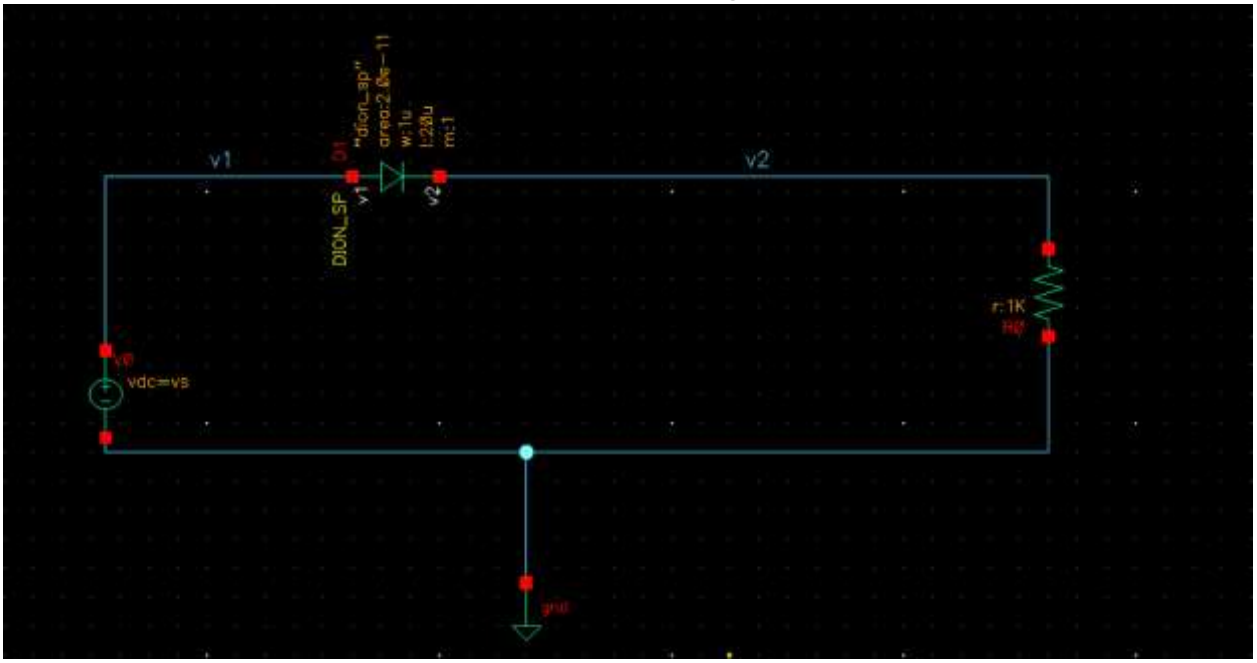
- Add the voltage source (VDC) and put its name to be "vs" so it can take different values during the Dc analysis.



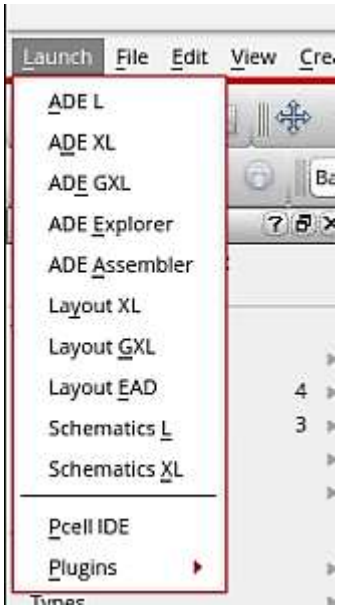
- Add a resistor of the required value (don't forget the ground)
- The new part of this experiment is to add a diode as shown in the coming figure.



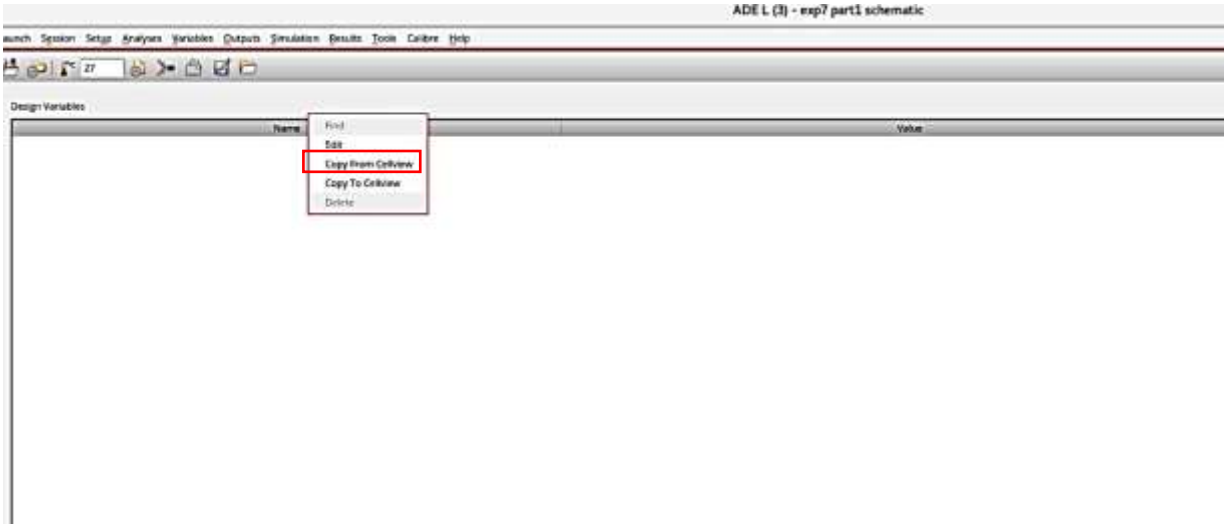
- The circuit will be as shown in the figure:



- Click save and check.
- From Launch choose ADE L

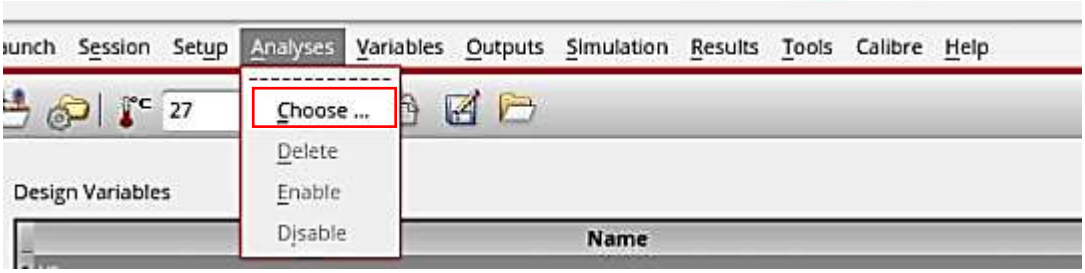


- Right-click and choose “copy from cellview” as shown in the figure below.

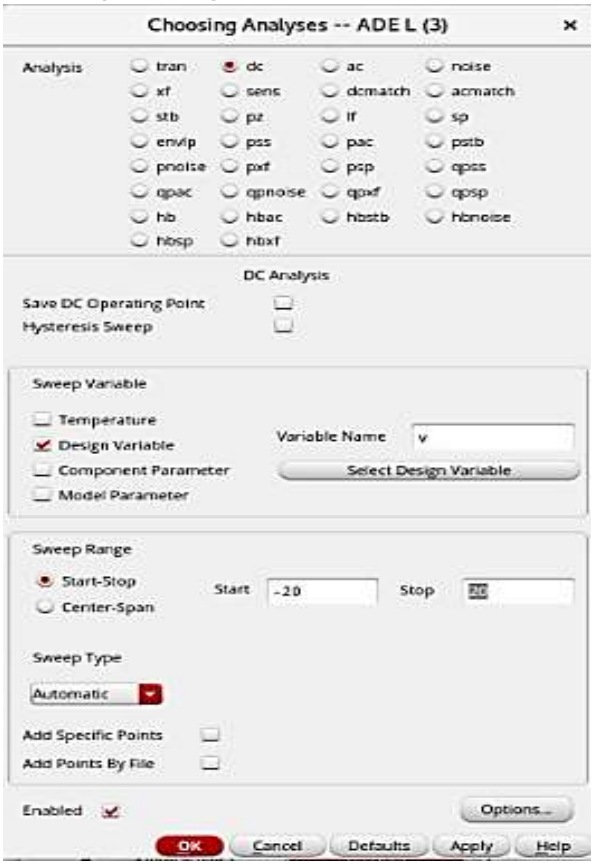


- “vs” will appear and put any value in the value section.

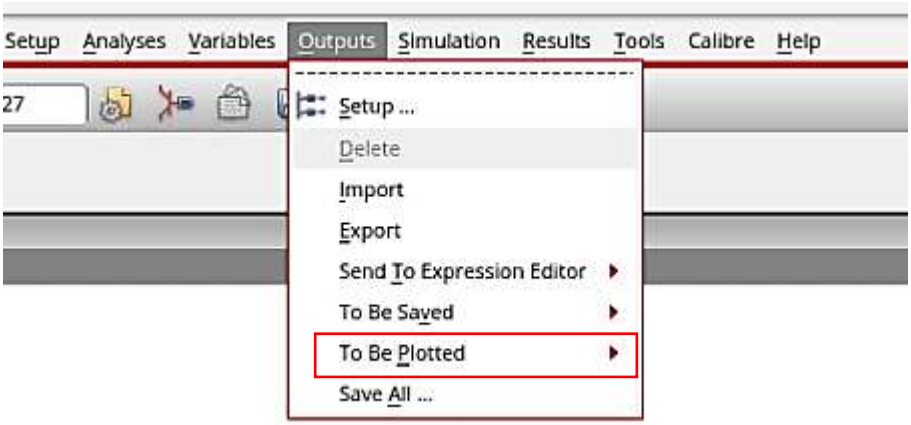
- Do the following:



- Adjust the following settings as it is.

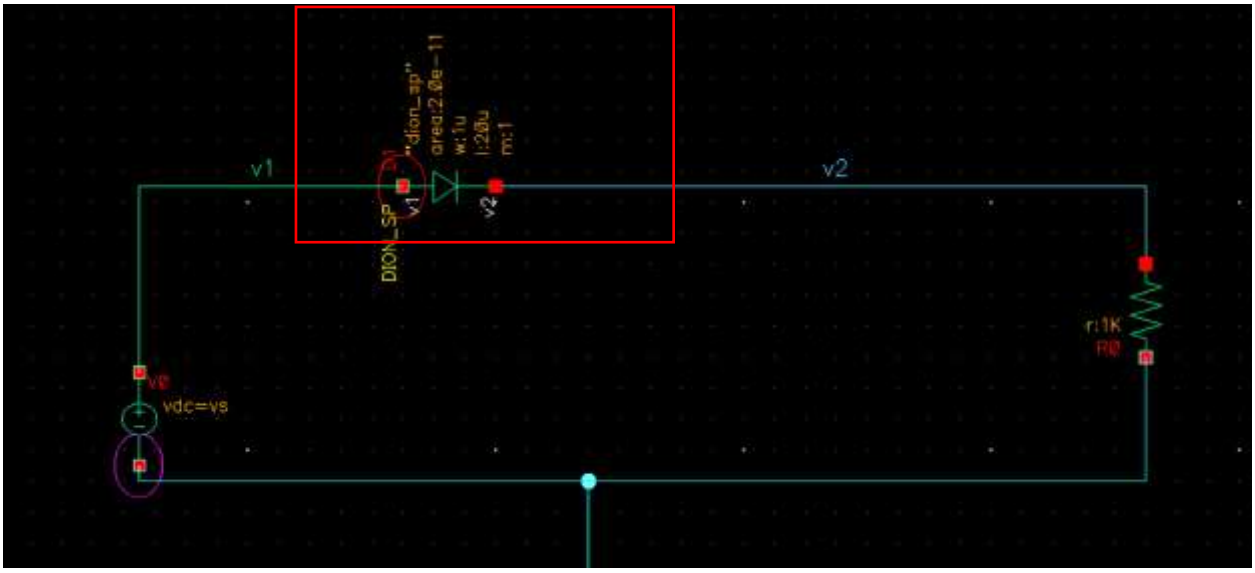


- Run the simulation.
- Choose to be plotted.

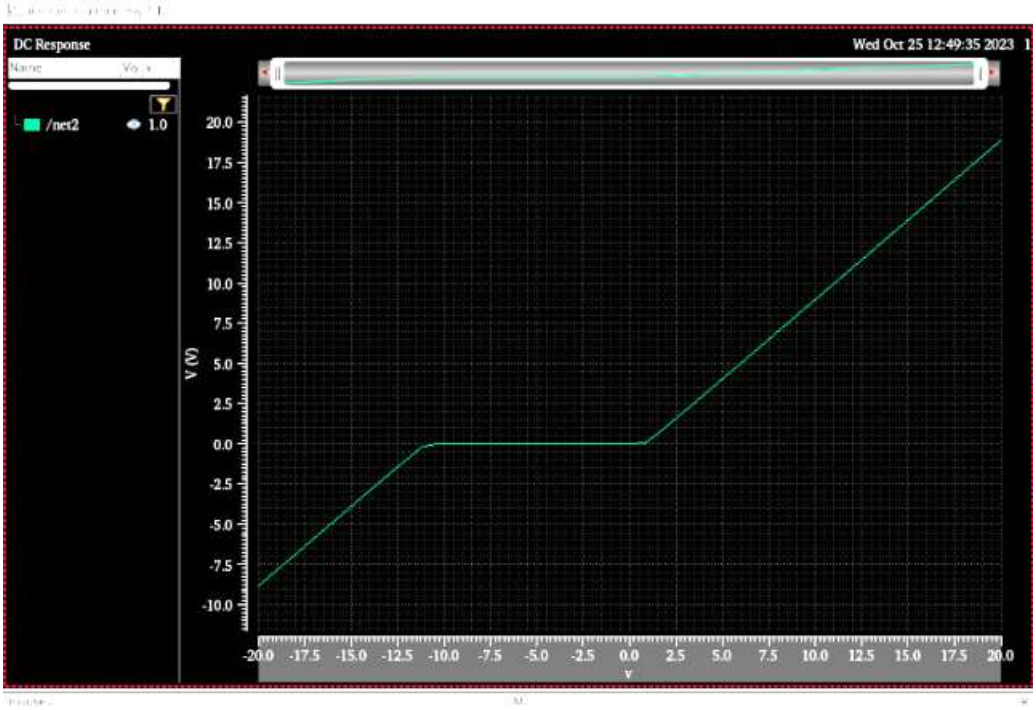


- Choose “select from design”.

- Then choose any node to take current from.



- plot the output.



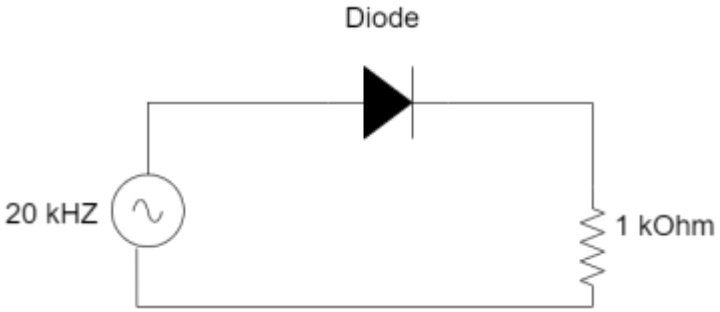
B- Rectifier:

Rectification is the conversion of alternating current (AC) to direct current (DC). This involves a device that only allows a one-way flow of electrons. As we have seen, this is exactly what a semiconductor diode does. The simplest kind of rectifier circuit is the half-wave rectifier. It only allows one-half of an AC waveform to pass through to the load.

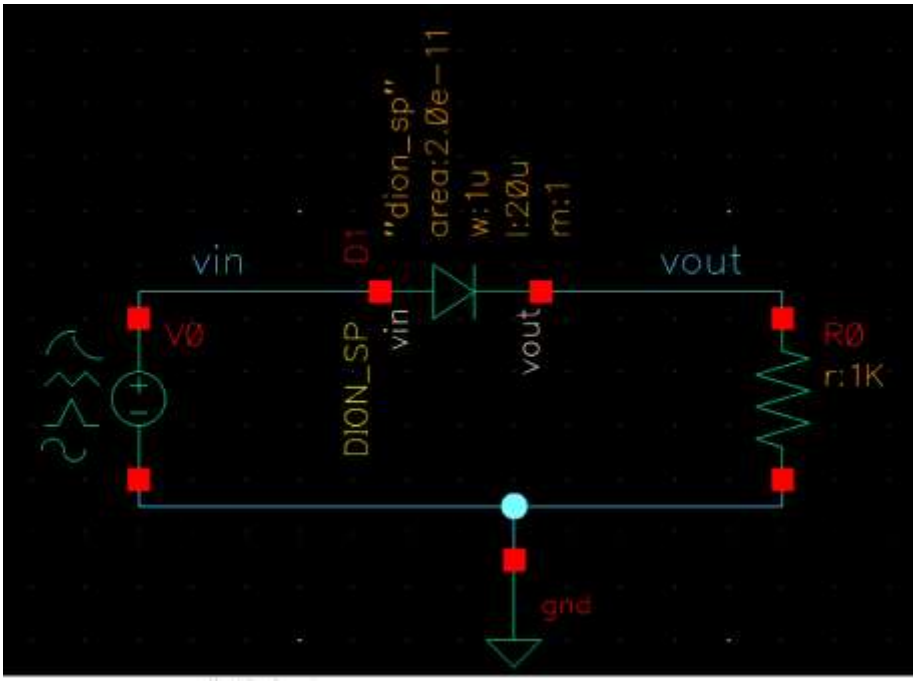
1. Half-wave rectifier

I. Experiment:

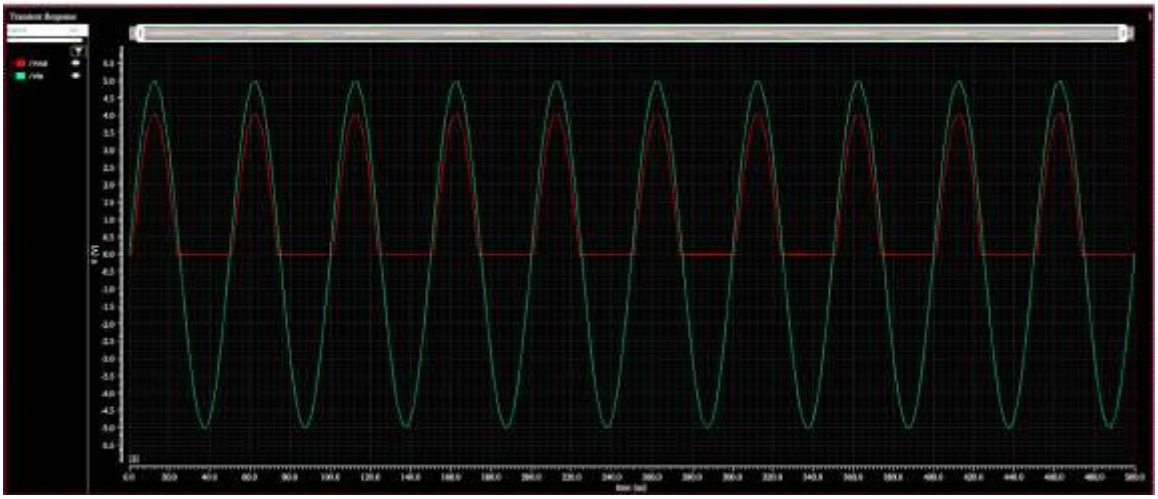
- Consider the circuit as the following figure.
- You are required to plot Vin and Vout=VR.



- Choose the components as in the previous part to construct the circuit above choose suitable values as indicated in the following schematic and choose AC peak voltage = 5 V.

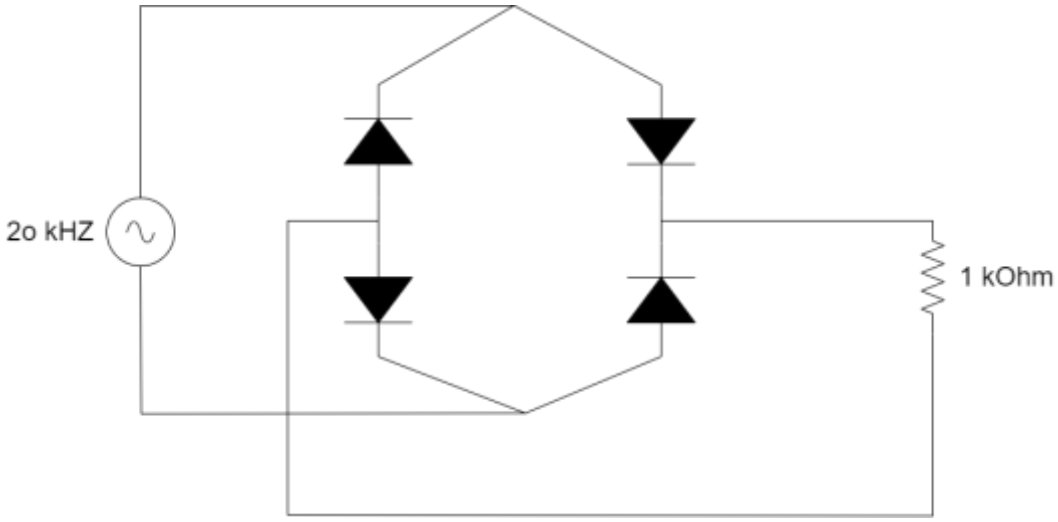


- Choose transient analysis and set a reasonable stop time.
- Plot Vin and Vout.

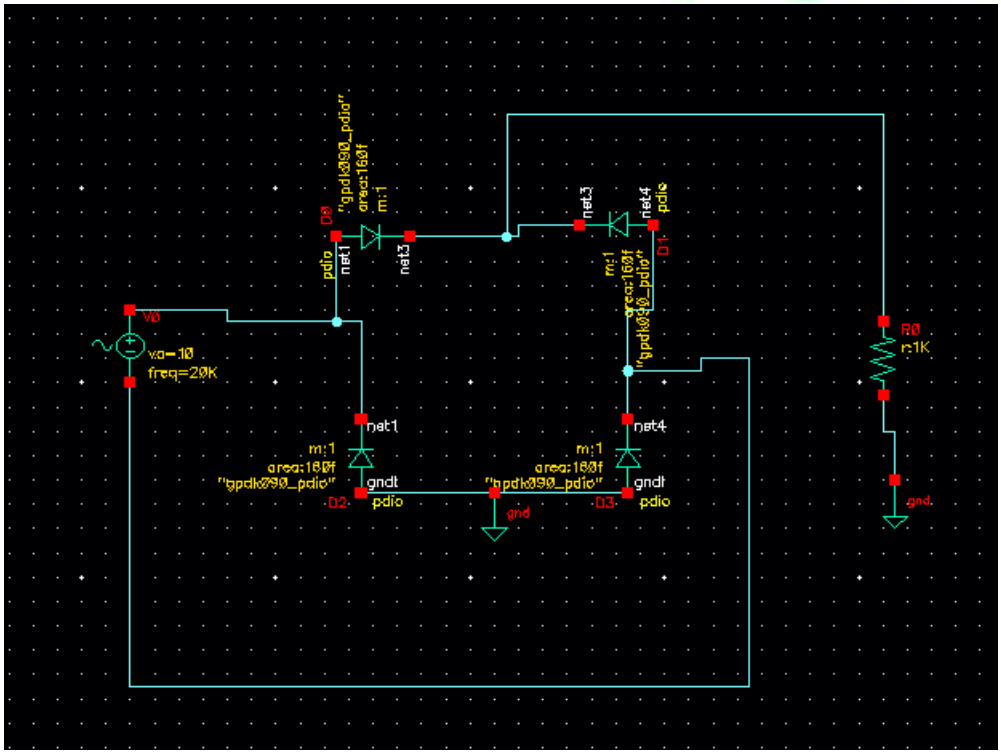


2. Full-wave bridge rectifier:

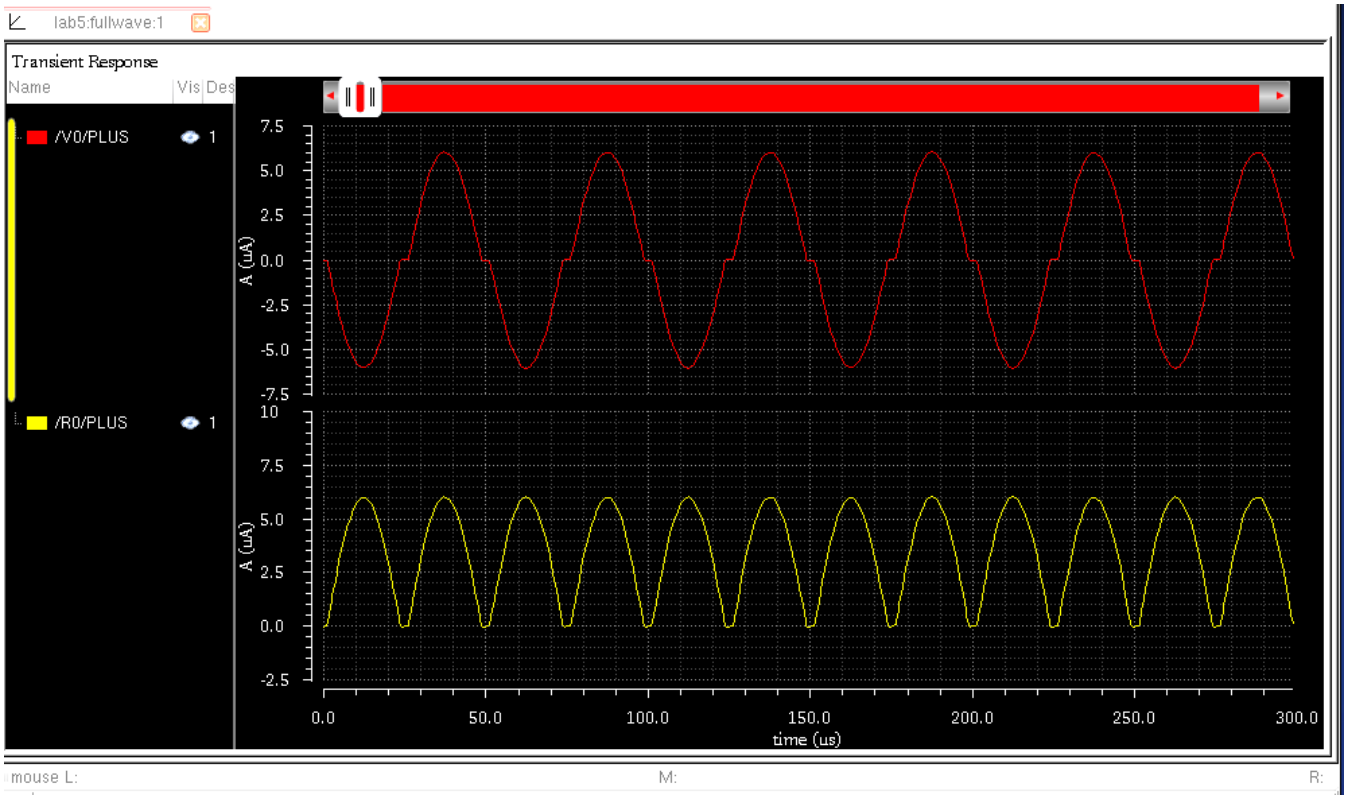
- Consider the circuit as the following figure.
- You are required to plot Vin and Vout=VR.



- Choose the components as in the previous part to construct the circuit above and choose suitable values as indicated in the following schematic and choose AC peak voltage=5 V.



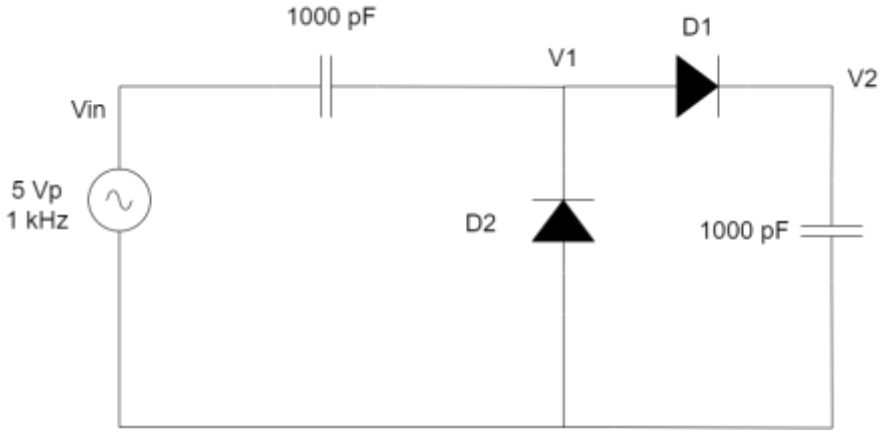
- Choose transient analysis and set a reasonable stop time.
- Plot Vin and Vout.



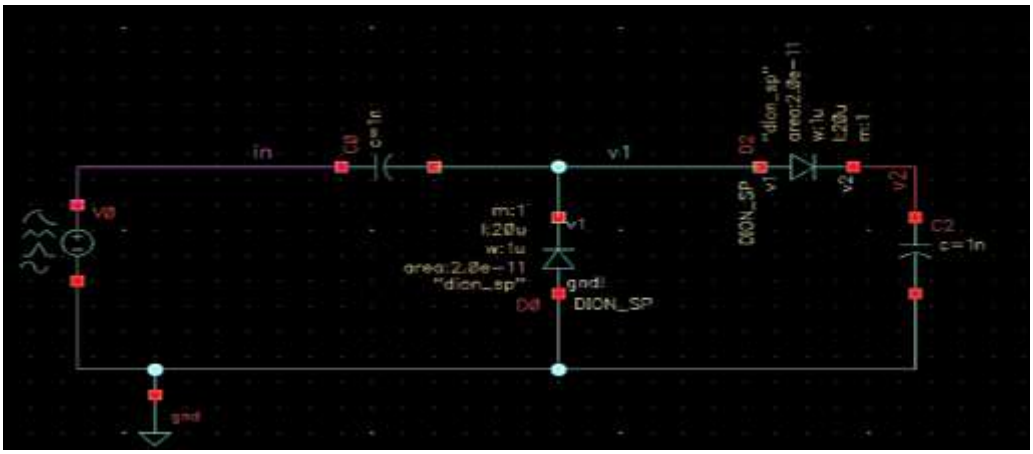
Voltage Multiplier

a voltage multiplier that is a specialized rectifier circuit producing an output that is theoretically an integer time of the AC peak input using half and full wave rectifiers.

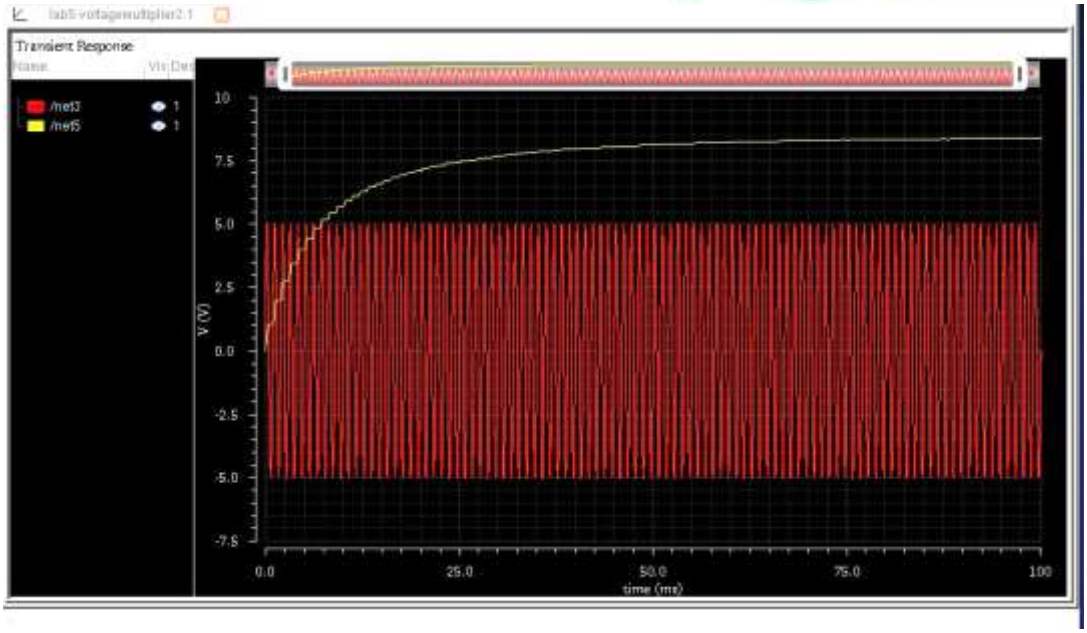
a. Half wave



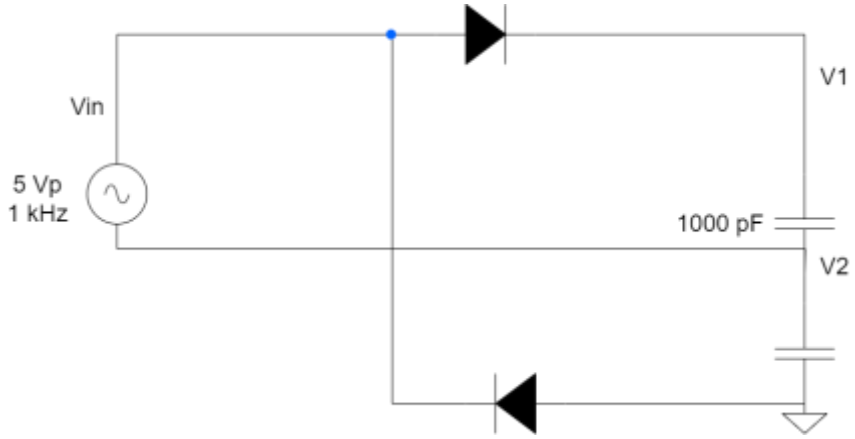
Half-wave voltage doubler is composed of a clamper and a half-wave rectifier.



Run the simulation and plot (in, v1, v2) and you will find the following plot.

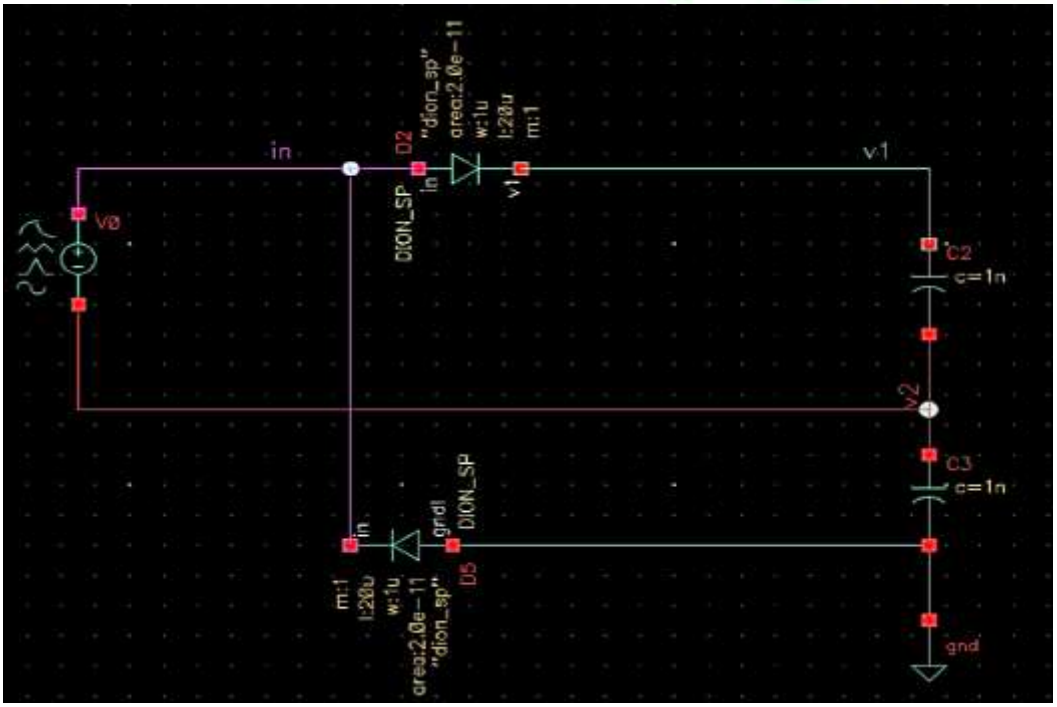


b- Full wave

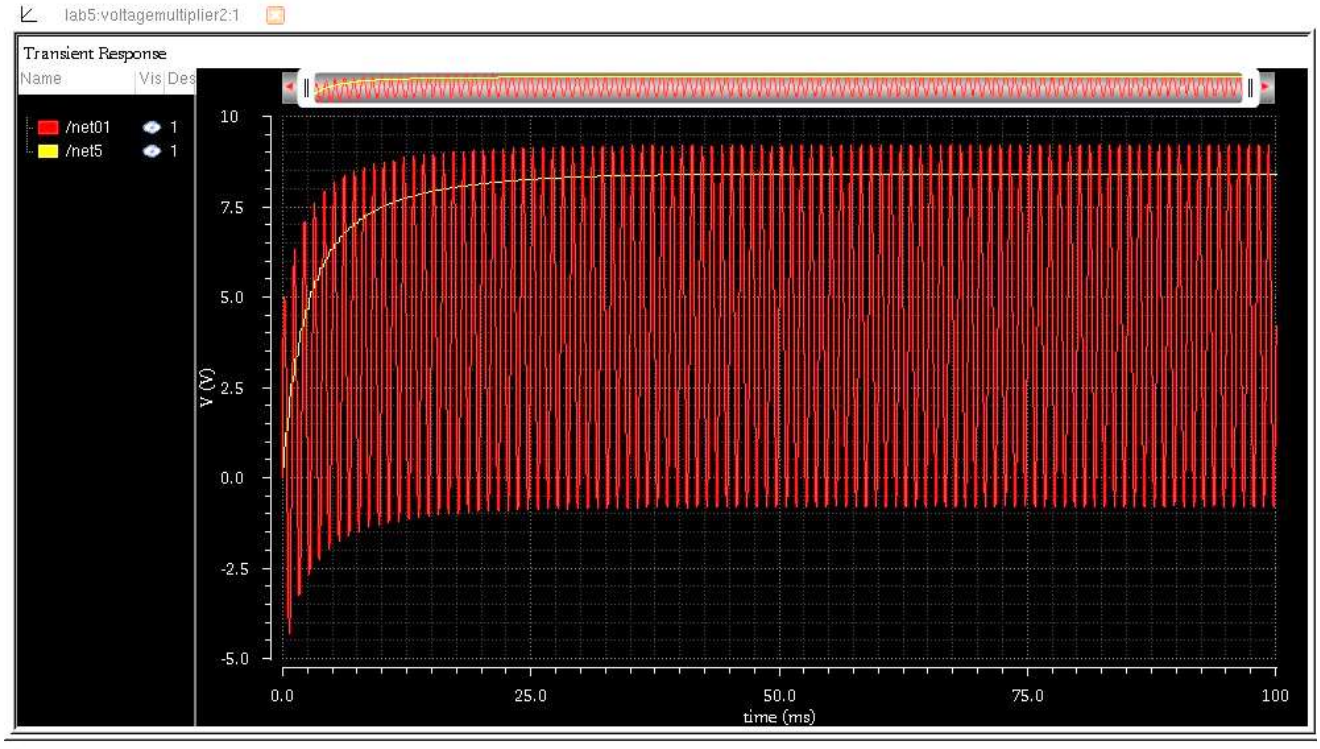


Full-wave voltage doubler consists of two half-wave rectifiers operating on alternating polarities.

- Construct the circuit and run the simulation.



- The plot will be the same as the following plot.

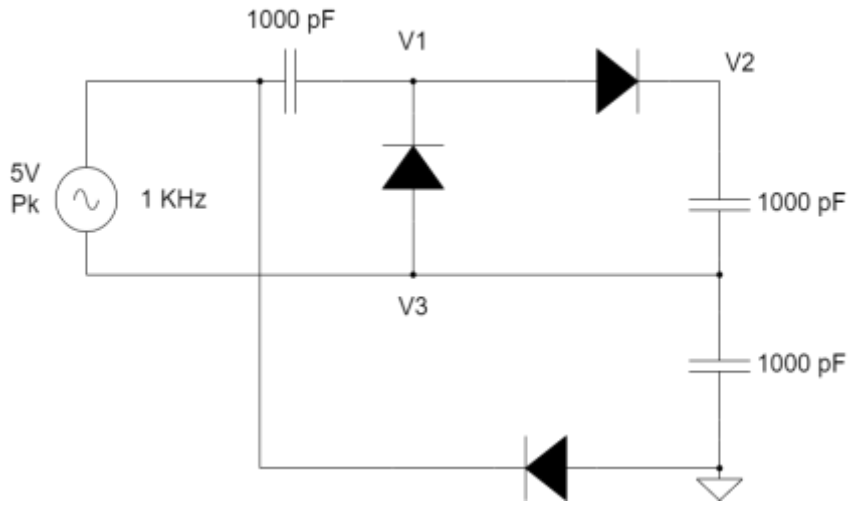


Assignment 5

-Design a voltage Tripler that is built from a combination of a doubler and a half-wave rectifier as indicated in the following figure.

Report the following:

- Schematic for the circuit on Cadence.
- Plot input and output signals.
- Record your own comment of output response



Bonus Questions of Lab 5

In this question, you are required to simulate an AC signal peak detector using half wave rectifier circuit & one passive component and

Report the following:

- Schematic for the circuit on Cadence.
- Plot input and output signals.
- Record your own comment of the output response