LTspice Basic Simulation Exercises

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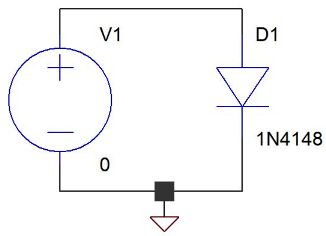
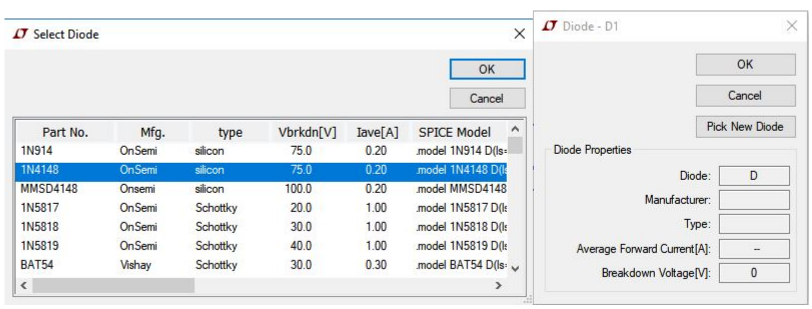
December 2, 2017

Rectifiers

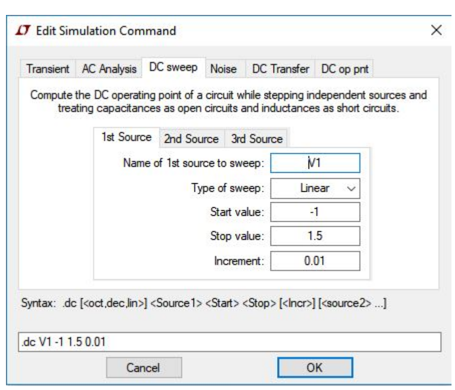
- Create a new schematic and draw the following



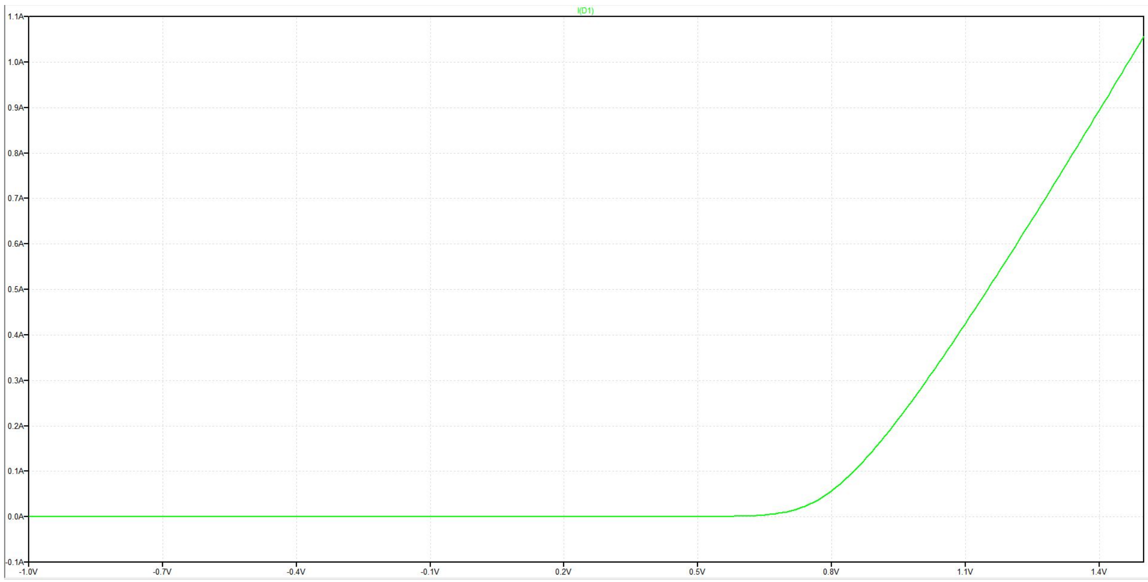
- Add the diode using the diode icon  or the shortcut key *D*. Right click the diode and choose the 1N4148 diode (a commonly used diode) after clicking *Pick New Diode*.



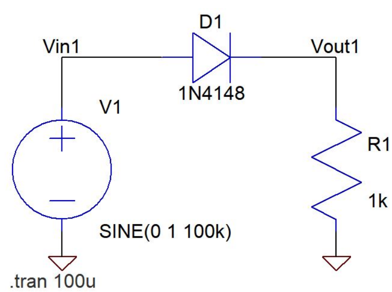
- Let us first get the I-V characteristics of the diode. For this, we need to sweep the voltage source *V1* and measure the current through the diode. Use the *DC Sweep* option in the simulation command to do this.



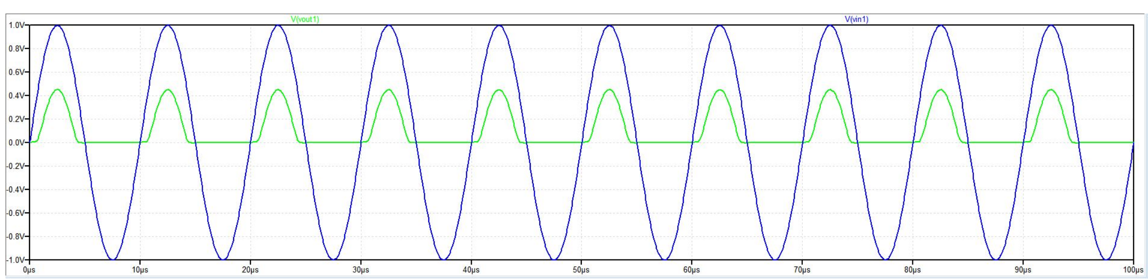
- Run the simulation and probe the diode current. We see the expected diode behavior.



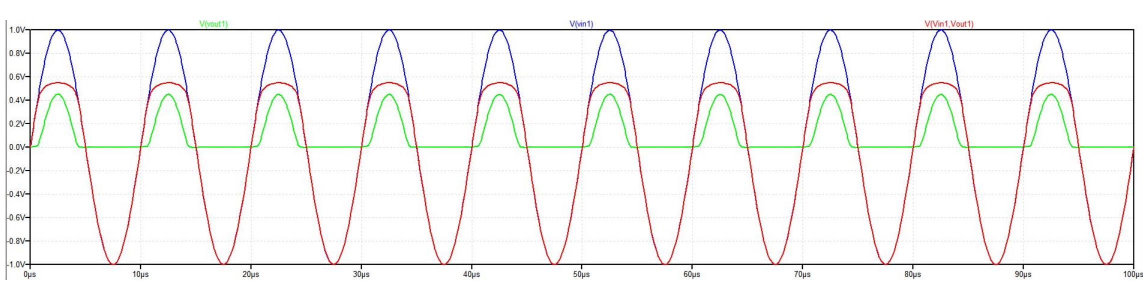
- As you can see, diodes have a rectification property, allowing current to flow in only one way. We can exploit this to make a rectifier. Modify the circuit to the one below and run a transient simulation for $100\mu s$



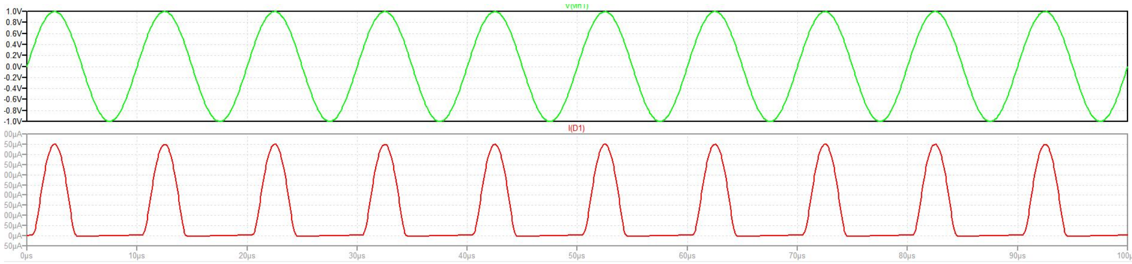
- Probe *Vin1* and *Vout1*. As you can see, the output wave is only generated in the positive cycle. This circuit is called a half wave rectifier. Also note that a part of the voltage drops across the diode, so the output is not exactly equal to the input in the positive cycle.



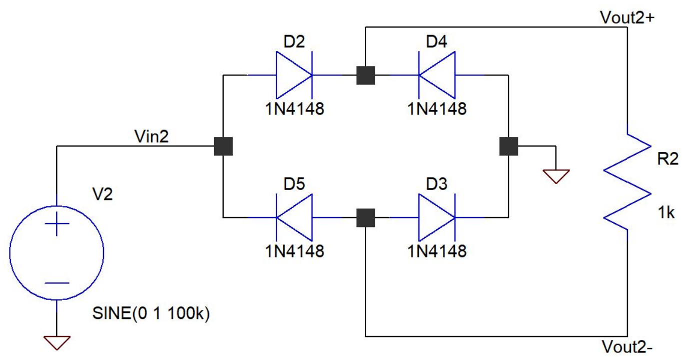
- Probe the voltage drop across the diode. Now you can see that the output voltage (green) is the difference between the input voltage (in blue) and the diode voltage drop (red).



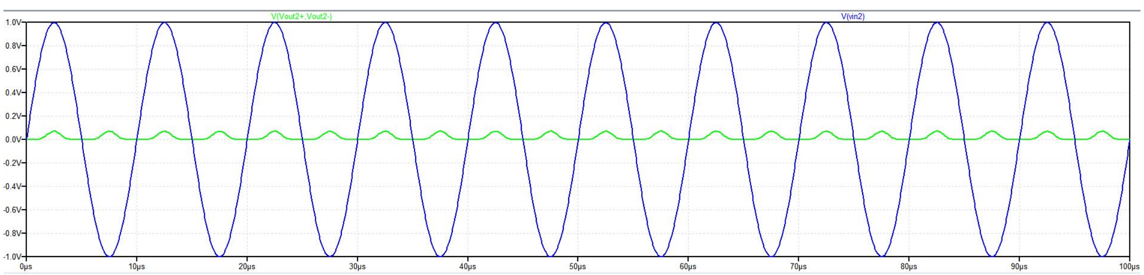
- Also, probe the diode current and the input voltage. You can see the rectifying action of the diode as it conducts current only during the positive cycle.



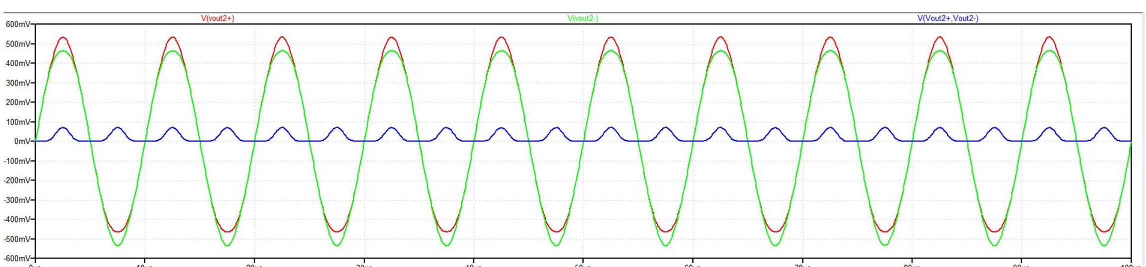
- Now, modify the circuit as follows and run a transient simulation for $100\mu s$



- Probe *Vin2* and the voltage drop across the resistor. Now we see that the output is rectified in both the positive and negative cycles of the input. However, now there are effectively two diodes in the path of current flow during either cycle, causing a larger voltage drop.

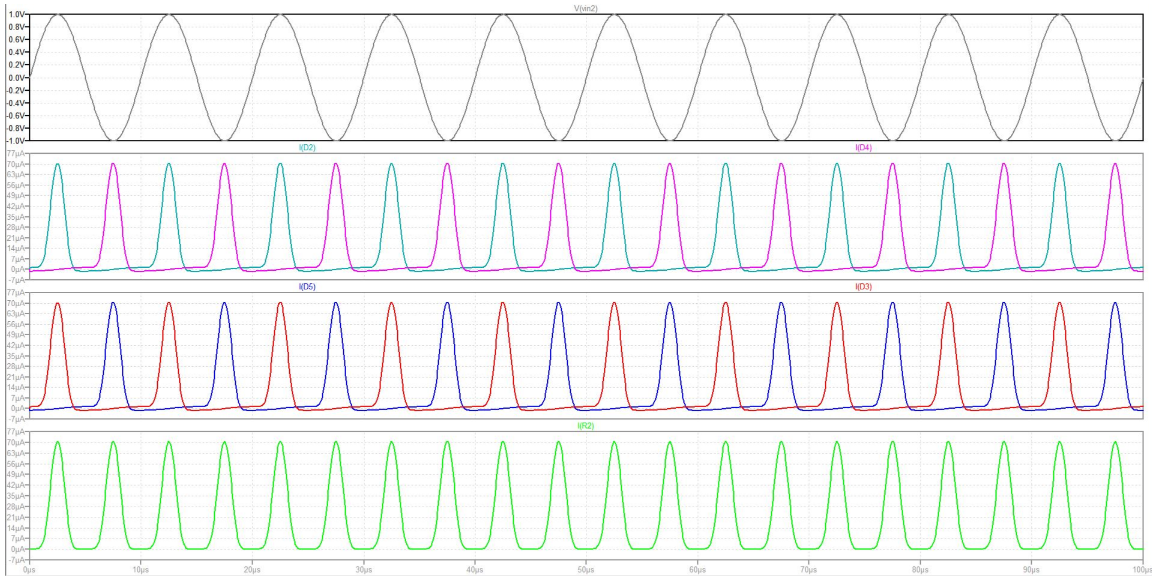


- Probe *Vout2+*, *Vout2-* and the voltage across the resistor.

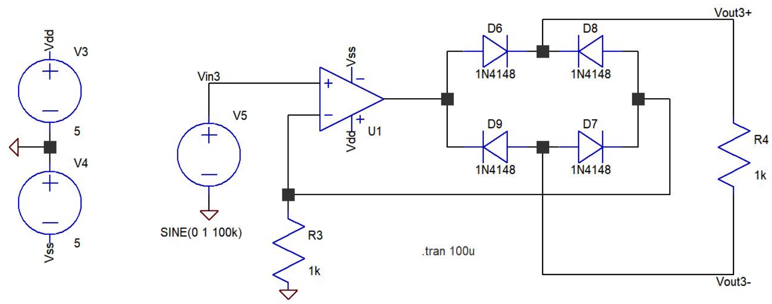


We can see that in both cycles, *Vout2+* is always larger than *Vout2-*, which causes a positive voltage to develop across the resistor in both cycles.

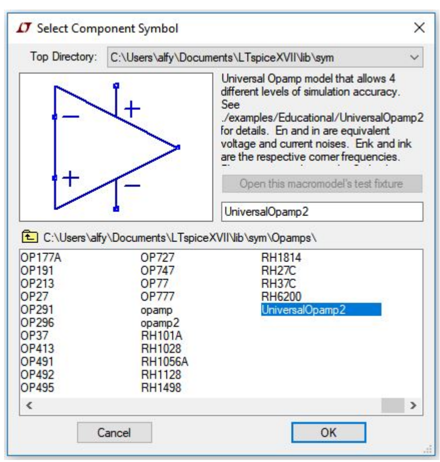
- Probe the input voltage and current through the diodes and resistor. We can see that in the positive cycle, current flows through diode *D2* and *D3*, while in the negative cycle, current flows through diode *D4* and *D5.* And in both cases, current flows only in one way through the resistor, which causes full wave rectification. This circuit is called a full wave rectifier.



- Modify the circuit to the one below.



- Use the *Add Component* dialog box to add the Opamp. Use *UniversalOpamp2*. Flip and rotate it to get it in the usual orientation.



- Run the transient simulation for $100\mu s$ and probe the input voltage and voltage across the resistor ($R4$).

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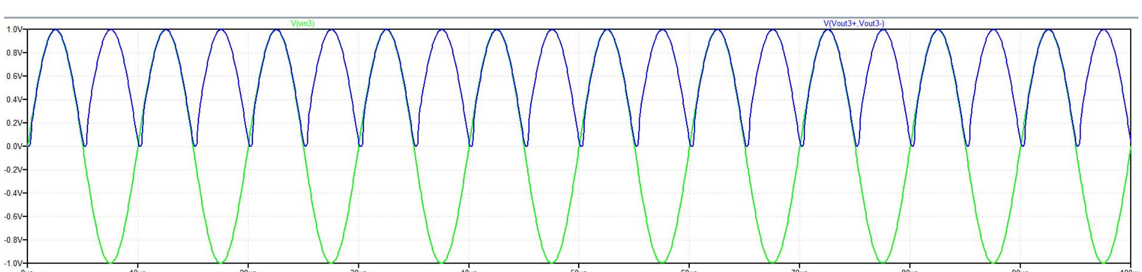
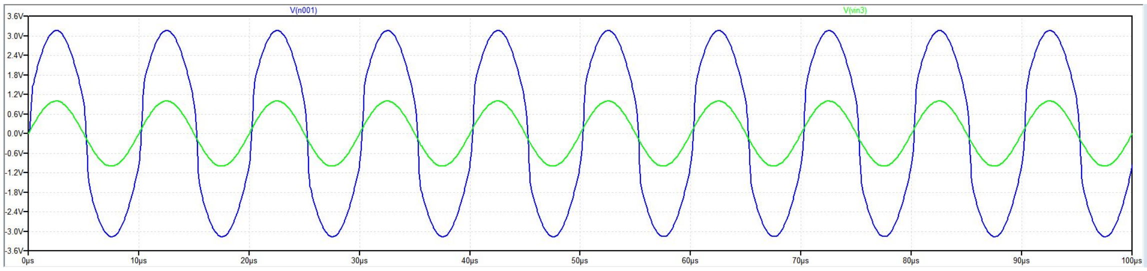


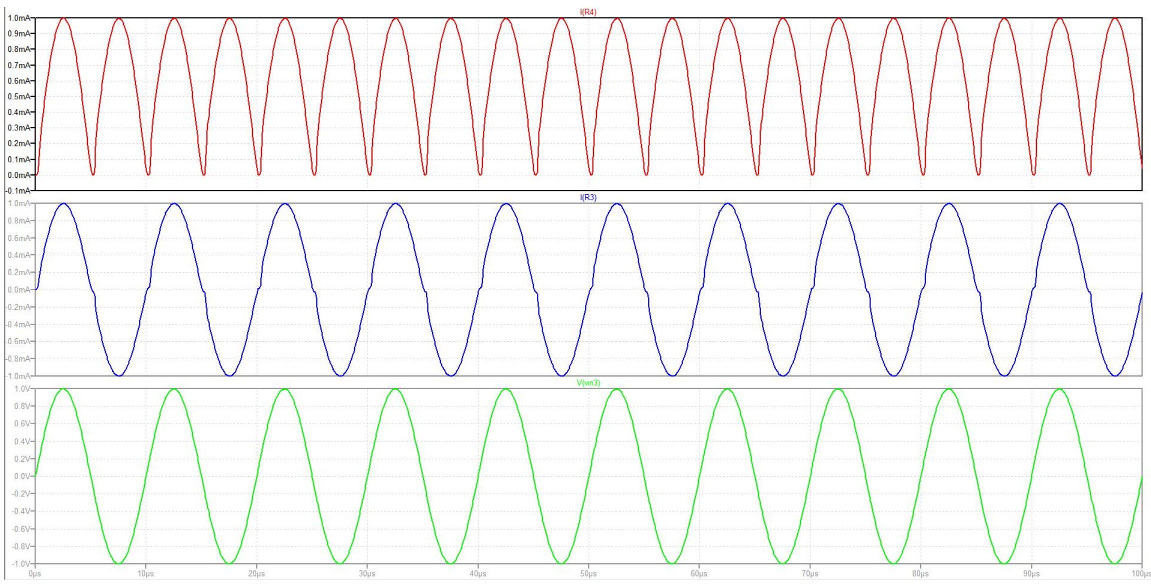
We see that the output voltage is full wave rectified and the magnitude of the wave is same as that of the input wave.

- Probe the input voltage and the voltage at the output of the opamp.



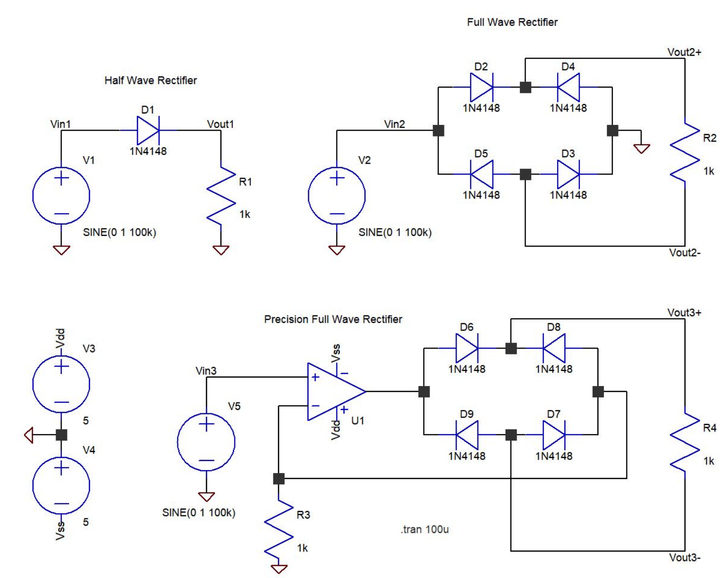
We can see that the opamp compensates for the diode voltage drops and hence, we get the proper voltage at the output.

- Plot the input voltage, current through resistors *R4* and *R3*



Through negative feedback, the opamp forces the voltage across *R3* to be equal to the input voltage. This causes a current to flow through *R3*, which is not rectified. The rectifying nature of the diodes forces this same current to flow through *R4*, but only in one direction. Hence this causes the voltage across *R4* to be equal to the proper expected rectified input waveform. If *R3* and *R4* were different, we can also get an amplified/attenuated and rectified version of the input waveform. This circuit is one implementation of a precision full wave rectifier.

- The final circuit is shown below.



- Note that in the case of the precision rectifier we are not interested in rectifying the AC voltage into DC for creating a DC power supply (here, the power comes from the opamp power supply). We merely want a proper rectified version of the input signal. However, the half wave and full wave rectifiers can be used (with other components) to create a stable DC power source.