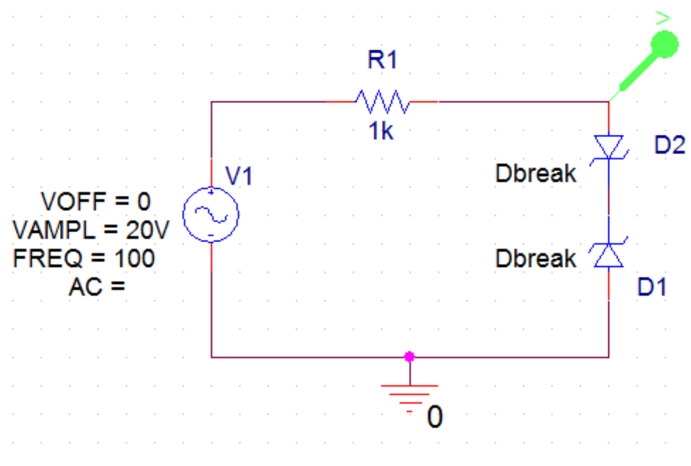
PSPICE tutorial: Zener diodes & editing parts

In this tutorial, we will examine the use of Zener diode in PSPICE and learn about editing the properties of devices.

This tutorial is written with the assumption that you know how to do all of the basic things in PSPICE: starting a project, adding parts to a circuit, wiring a circuit together, using probes, and setting up an using a simulation profile.

Build the circuit

Build the circuit shown at right. Use the "DbreakZ" device from the Breakout library for the two diodes The source is a VSIN with amplitude of 20 V and frequency of 100 Hz.



Set up a transient simulation that will run over a period of 50 ms (5 periods of the sine wave). Set the maximum step size to be 0.1 ms, giving 500 points in the simulation so that the traces in the graph will be smooth.

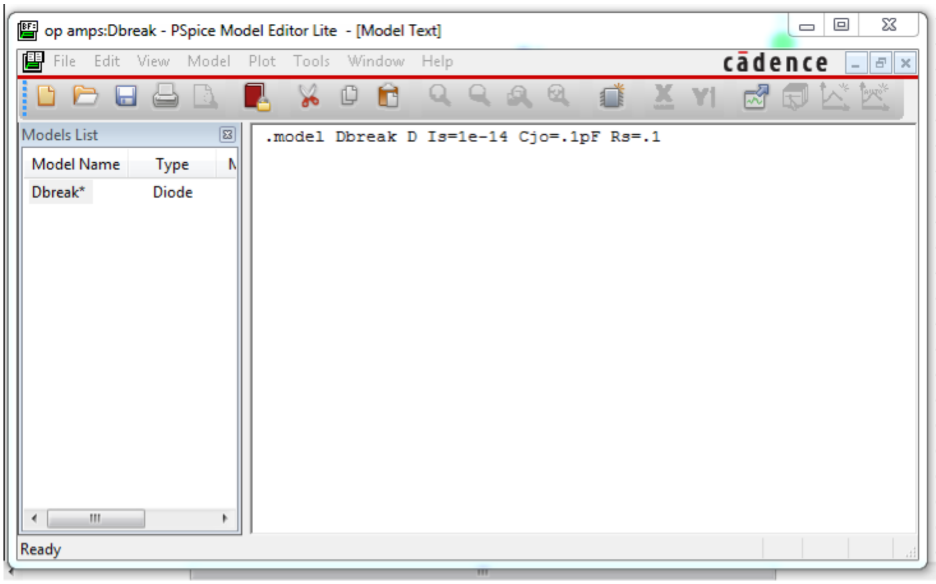
What to we expect from this circuit? When the sinusoid is positive, diode D2 will be forward-biased and D1 will be reverse-biased. There will be no current flow unless D1 goes into its breakdown mode. If D1 breaks down, then the total voltage across the diodes will be clipped at the breakdown voltage plus one forward diode drop: $V_B + 0.7$. During the negative half-cycle, the opposite happens: D1 is forward-biased and D2 reverse-biased. No current flows unless D2 breaks down, in which case the voltage will be clamped at $-(V_B + 0.7\text{ V})$.

Of course, this begs the question: What is the breakdown voltage of the diodes used in the circuit?

If we try running the simulation, we see that the output is a 20-V sine wave at 100 Hz – the output is exactly like the input. It appears that the Zeners are not breaking down at all.

At this point, we learn that PSPICE is pulling a bit of a fraud on us. It turns out that there is no breakdown voltage for these diodes, even though they are advertised as Zeners. To see the problem and fix it, we need to edit the model for the diodes.

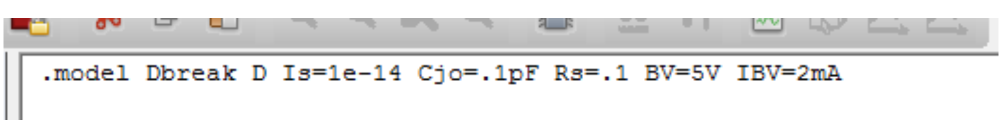
To do that, click on one of the diodes to select it. Then right-click on the selected diode and from the pop-up menu, select “Edit PSPICE model”. A dialog box opens that contains one line of text, as shown below.



The line of text describes the properties of the model being using by PSPICE. The name is “Dbreak”. The “D” means that it is a diode. The parameter “Is” is the saturation or scale current of the diode, as we have discussed in class – it is has the typical default value of 10^{-14} A. The parameter “Cjo" describes something about the capacitance of the diode. (An EE 332 topic.) Finally, “Rs” is the series resistance due to wiring and contacts.

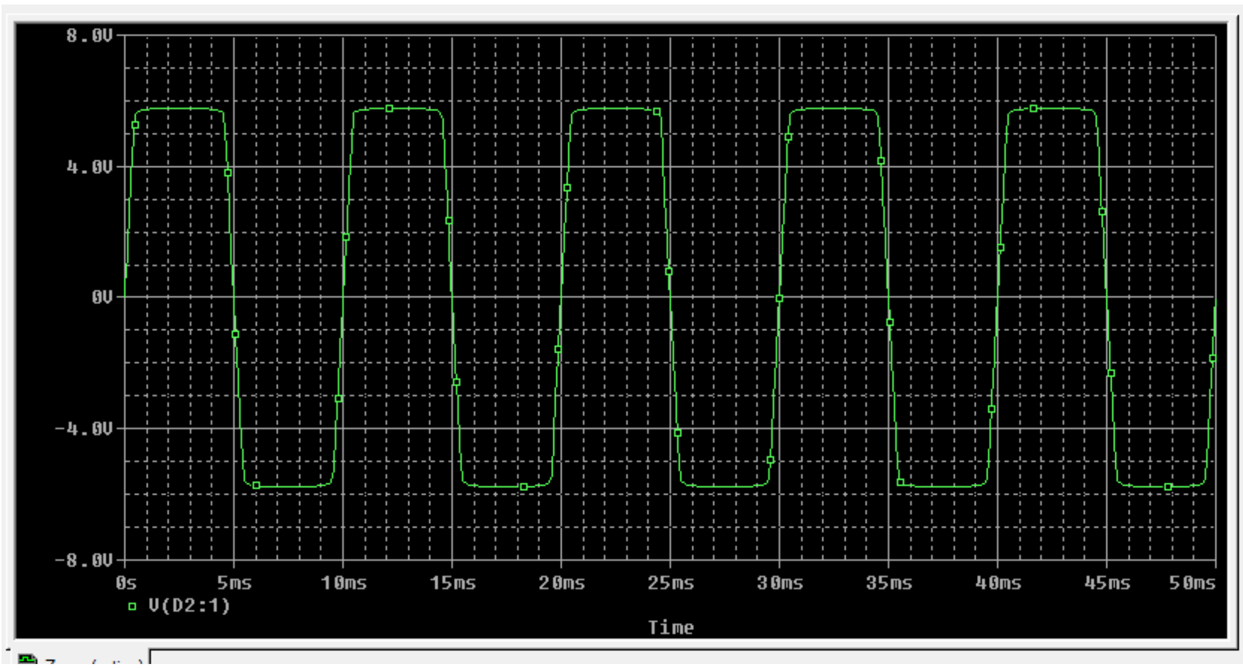
There is nothing in the description about breaking down! To fix that, we need to add parameters to describe the breakdown. Let’s assume that we are trying to model a 5-V Zener. In that case we would add the following at the end of the line of text above: BV=5V IBV=2mA. These two parameters describe one point on the breakdown curve – at 5 V reverse bias, 2 mA of current of reverse current will flow. This is enough information to tell PSPICE what to do. (Note the current is not essential. If we simply entered BV=5V, that would be enough to cause breakdown in the simulation. Adding the current parameter makes the model more accurate.)

So let’s add that text and then save the model info – choose “Save” under the File menu. Then we can close the window. (Note: The file must be saved before closing the window, otherwise the changes won’t stick.)



It is important to realize that when we change the model parameters, they are changed for *every* diode that uses the DbreakZ model. So by changing one, we change both diodes in the circuit. Furthermore, it is changed for all future diodes that use the DbreakZ model. If we use DbreakZ in a future circuit, it will have the 5-V breakdown. If we ever want to have two different Zener diodes in some circuit, we will have to define a completely separate model that describes the properties of the second Zener. We will bump into these kinds of issues later as we deal with other devices.

Now that we have changed and saved the properties of DbreakZ, let's run the simulation again.



Now we see that the output voltage is clipped off at approximate ±5.7, just like we expected.

If we want to model a 15-V Zener diode, we simply go back and change the BV parameter in the description of the DbreakZ device.

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.model Dbreak D Is=1e-14 Cjo=.1pF Rs=.1 BV=15V IBV=2mA
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Re-running the simulation with the larger breakdown voltage leads to the expected change in the output.