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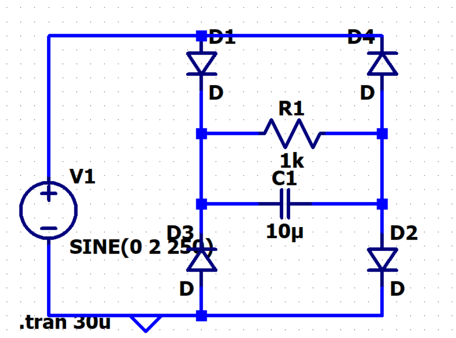
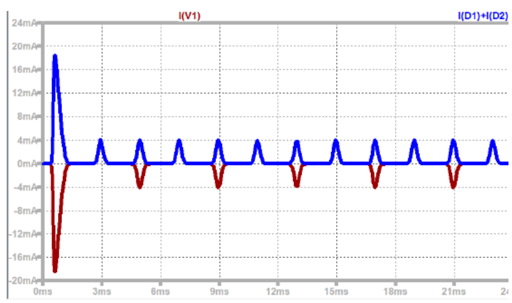
IE lab 3 part2

Pre Lab Exercise 2:

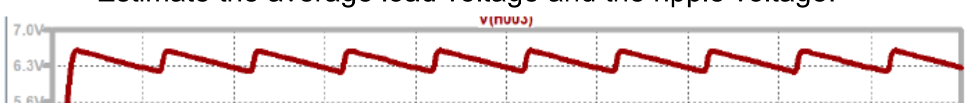
1) In Spice, implement one of the Exercise 2 diode circuits (Figure 3, shown below). Set the source voltage to a 250 Hz, 4 Vpp sinusoidal signal. Recall: P = VRMS × IRMS = IRMS 2 × R = VRMS 2 / R. Also recall, for a sinusoidal wave: VRMS = VAmplitude / 21/2
   Use current probes to plot the current (versus time) at the source, and at the load.
   Estimate the average power provided by the source, and the average power consumed by the load.
   How efficient is the power conversion (i.e., output power / input power) of the full wave rectifier?





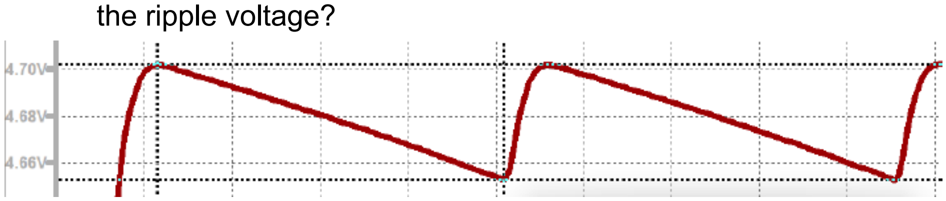
Ps=VsRMS*IsRMS = 2V/sqrt2 * 4.1*10^3/sqrt2=4.1mW
Pl=VlRMS*IlRMS = 1.31V/sqrt2 * 4.1*10^3/sqrt2=2.69mW
2.69/4.1=.65, 65% efficient

2) Implement in Spice the half-wave rectifier circuit shown below (Figure 4). Use a source voltage V1 with VOffset = 0 V, VAmplitude = 8 V, and f = 250 Hz.
   Plot the load voltage versus time.
   Estimate the average load voltage and the ripple voltage.



VlRMS = 6.3V
Vlripple = .4Vpp, .2Va

3) Add a Zener diode (part number D1N751) in parallel with the load as shown below. Use a source voltage V1 with VOffset = 0 V, VAmplitude = 8 V, and f = 250 Hz.
   Plot the load voltage versus time. Estimate the average load voltage and the ripple voltage.
   What effect does the regulator (Zener diode) have on the average load voltage? And on the ripple voltage?

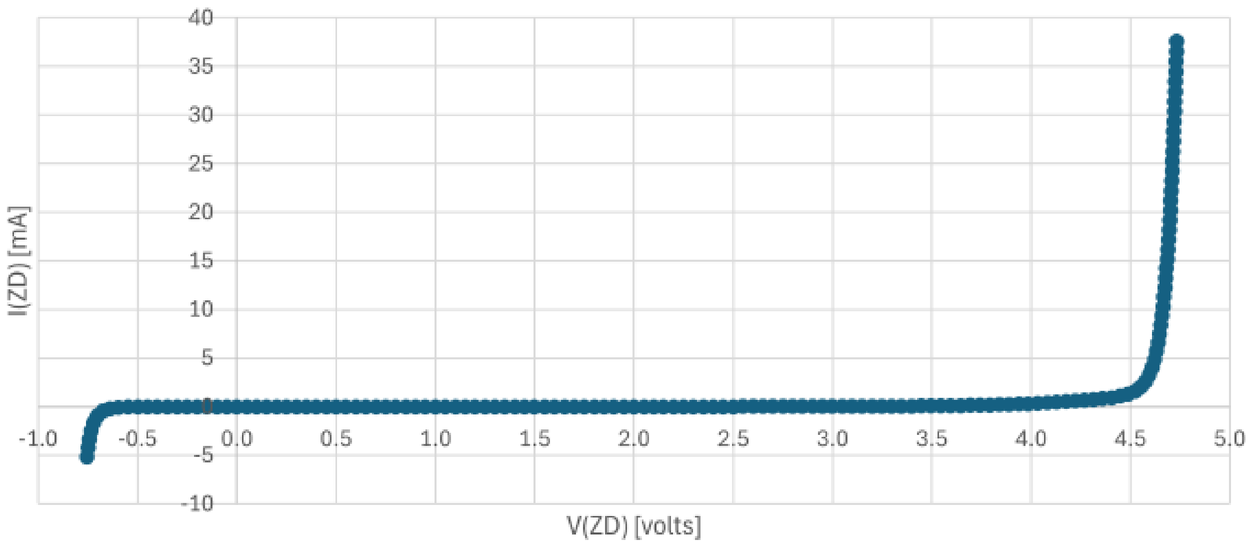


Note: using LTspice, used the 1N750 with Vz = 4.7V instead of 5.1V

VlRMS=4.68V
Vlripplepp=0.0488V, Vlripplea=0.0244V
The zener diode greatly reduces ripple and lowers the voltage to Vz, helping to smooth the output.

Exercise 3:

1) In Spice, build the circuit below (Figure 9). Use a DC voltage source for Vs and the D1N751 Zener diode in the DIODE library (refer to the introduction if you have not added the DIODE library). Sweep the source voltage from –1 V to 6.5 V and plot (versus source voltage) the current into the cathode of the diode. To sweep the voltage, select DC Sweep as your simulation type, pick the source by the name, and set the lower limit and upper limit. You should set the increment size so that your curve appears fairly smooth. Also, note that we are investigating the avalanche breakdown characteristics of the Zener diode when it is reverse biased.
   Plot the diode current against the diode voltage. Note, the DC sweep sets the horizontal axis to the DC sweep voltage. You can set probes to make measurements in PSpice and then save the raw data to plot in Excel, Matlab, etc.
   a) Set a current probe at one of the circuit nodes (the current through each component is the same)
   b) Set a voltage probe across the Zener Diode
   c) Run the DC sweep
   d) On the Schematic window (plot window), select File in the upper right corner.
   e) Choose the Export option and save the data as a ‘csv’ file.
   f) Generate and IZD-versus-VZD plot using your favorite tool (ZD = Zener Diode)



Again, using a diode with Vz=4.7V, not 5.1V

Diode is measured in the opposite direction, so this is measuring reverse bias, the whole graph is essentially negated.

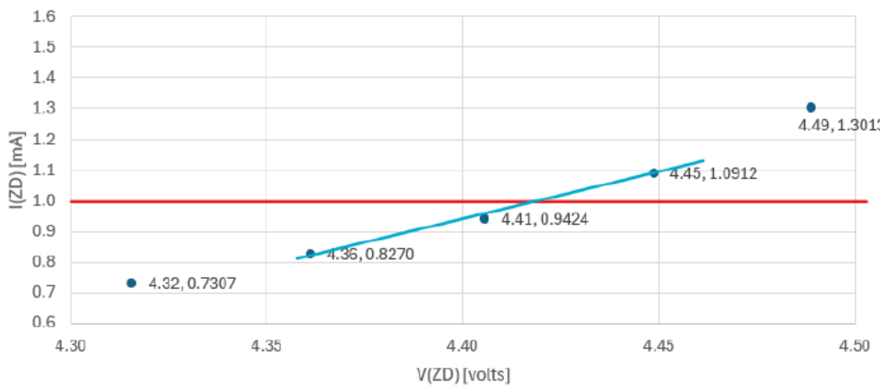
2) Beyond the “knee voltage” and “knee current” the Zener diode is in reverse breakdown (commonly the desired operating regime). Estimate the Zener diode’s knee voltage, VKnee , and knee current, IKnee .
How does your PSpice value compare to the spec sheet values for the 1N751?

4.70	19.1955
4.70	20.2016
4.70	21.2104

Vknee=4.7V, Iknee~=20mA
This matches the specs of the diode we used, 4.7V and 20mA

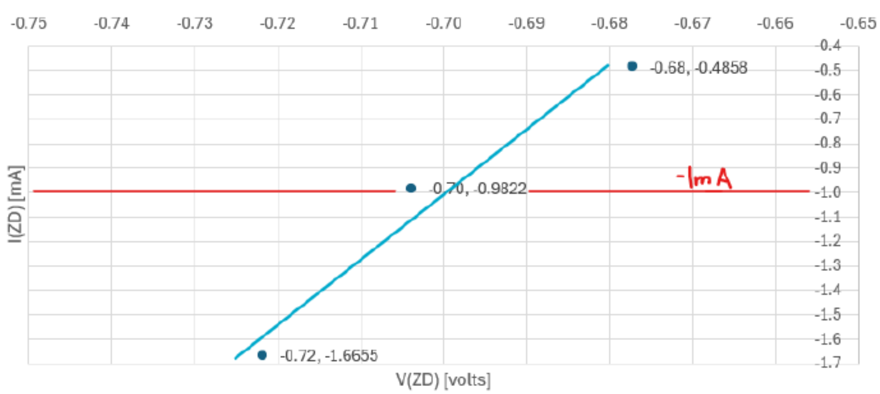
3) Determine the Zener diode's differential resistance (rZD) at (i) a reverse breakdown current of 1 mA and (ii) a forward current of 1 mA. Recall: rZD = dV/dI.
Is the forward differential resistance consistent with the formula derived in class (rD = Vt / I)? Compare the forward and reverse differential resistances. What are your findings?

Reverse:



rZDreverse=Vdiff/Idiff=340.65 Ohms

Forward:

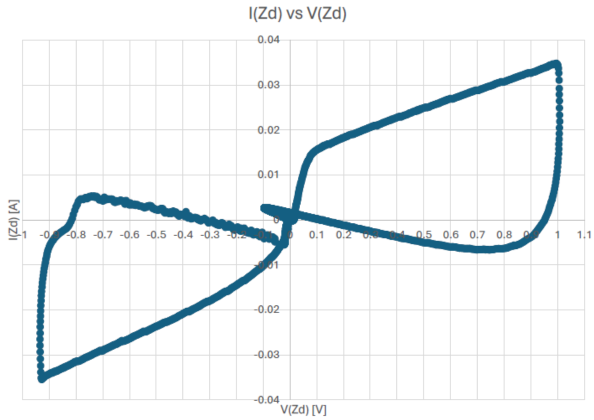


rZDforward=Vdiff/Idiff=33.9 Ohms

rD=Vt/I=.026/1m=26 Ohms, fairly close to our measurements for forward.
We wouldn't expect this to apply to the reverse breakdown, as that happens at 4.7V, and indeed, rDreverse is about 10 times larger.

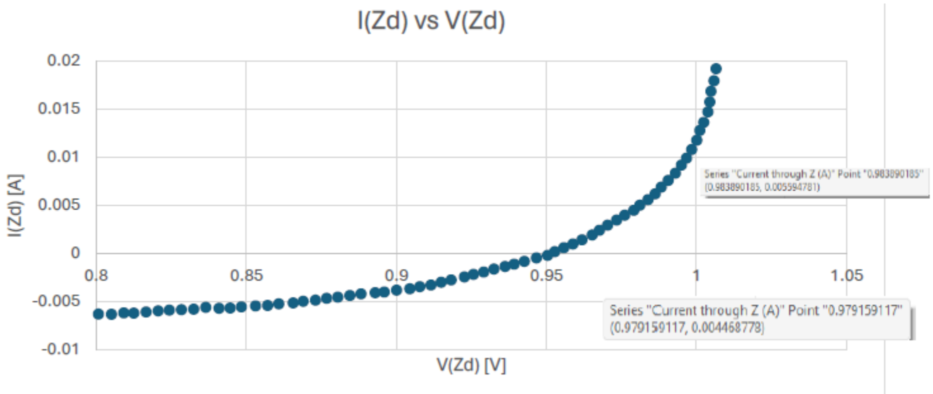
4) Build the circuit below (Figure 10) using the LF351/353 op-amp. Set the source to a 8 Vpp (4 V amplitude), 100 Hz triangle wave (sawtooth-shaped wave). The non-inverting op-amp is implemented such that we can provide voltage signals to the load circuit in excess of the 5 V limit internal to the Discovery Board/Mobile Studio. Use a +15/–15 V voltage to power the op-amp.
   As with Exercise 1, measure the voltage across the Zener diode and the voltage across the 47 Ω load resistor. Use the math mode to obtain IZD-versus-VZD plots for the Zener diode.

5) Download the raw data and obtain experimental estimates for the Zener diode's knee voltage (VKnee) and knee current (IKnee).



Vknee ~= 85V
Iknee ~= 5mA
It was hard to determine current due to our strange setup to get +-15V

6) Estimate the Zener diode voltages when the Zener diode current is 5 mA and 10 mA. Use this result to get an estimate of the reverse breakdown resistance, rZD. Are your results consistent with the spec sheet values?



5mA:
rZD=4.2Ohms
10mA:
rZD=2.103Ohms